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ECOLOGICAL SIGNIFICANCE OF THE DISAPPEARANCE OF EEL-GRASS AT CAPE ANN, MASSACHUSETTS[1]

Ralph W. Dexter
Kent State University, Kent, Ohio

A number of local and regional reports have been published on the widespread wasting disease of eel-grass (*Zostera marina*) in North America. Observations on the disappearance and annual status of beds along the Atlantic Coast have been recorded by Huntsman (1932), Lewis (1932), and Adams (1933) for parts of Canada; Taylor (1933) for the Woods Hole region; Cottam (1933, 1934a, b, 1935a, b, c, 1938, 1940), Renn (1936a, b, 1937), and Lynch and Cottam (1937) for the Middle Atlantic States; Stevens (1935) for Upper Buzzards Bay; and Young (1938) for the Mt. Desert Island region.

The eel-grass disappeared rapidly at Cape Ann, Massachusetts, in 1931–32, as elsewhere along the Atlantic seaboard, and was practically gone by the summer of 1933. Renn (1936a) has shown that the disease probably is caused by a protozoan (*Labyrinthrula* sp.), but all investigators have not yet accepted this as the final cause. Stevens (1936, 1939), Tutin (1938), and Young (1938) have shown certain environmental relationships to the wasting disease. Stevens has pointed out correlations between the three recorded periods of eel-grass scarcity with periods of extreme north declination of the moon (which probably affects ocean currents), and agrees with Young that changes in salinity may be important in explaining the disappearance. Tutin attributed the phenomenon to "enfeeblement of the plant due to lack of sunshine in 1931–32"; this thesis, however, has been refuted by Atkins (1938) and by Stevens (1939). It is generally believed, that some environmental change is partly responsible for the wide and sudden epidemic.

SITUATION AT CAPE ANN

Previously to 1931, eel-grass was abundant in extensive beds in the shallow coastal waters at Cape Ann and in a tidal inlet known as the Annisquam River. The writer studied the marine life there during the summers of 1933–37 and briefly during those of 1938 and 1940. Observations were recorded on the eel-grass situation with reference to its probable effect on marine life and marine communities. The only eel-grass seen in 1933 was a persisting colony in a shallow brackish side channel of the inlet (Goose Cove). This agreed with observations by Huntsman (1932), and Cottam (1933) that eel-grass was persisting in some local areas where brack-

[1] Clarence Cottam and Neil E. Stevens read the manuscript and made suggestions regarding its publication.

ish conditions prevailed, and that "those areas with a reduced salinity are [were] making the best return" (Cottam, 1934b). Stevens (1936) observed that eel-grass persisted longest near the mouths of rivers where the seawater was most dilute. Inquiries among fishermen, clammers, lobstermen, etc., did not reveal any other known occurrence. In 1934 several small patches and a few isolated plants were found in mud banks of the inlet at about the spring low-water line, but none of the plants was healthy in appearance. Dredging of the channel bottom was begun that summer and occasional fragments of *Zostera* were taken. In 1935 a number of colonies were discovered in mud and sand sediments along the channel near the low-water line; two were of about one square foot each, but the plants were streaked with brown. Several small clumps were dredged from a shallow lagoon north of the Annisquam lighthouse on Ipswich Bay. In 1936 the situation remained about the same with perhaps a few more patches. By 1937 small isolated patches were fairly common in the subtidal sediments. None of the colonies was very large and the plants were unhealthy in appearance, but several seedlings without marks of the disease were collected in shallow water. Fragments of blades were taken in bottom dredging and occasionally were seen floating on the surface, especially at the confluence of the inlet with Ipswich Bay. Cottam (1938) quotes a record of eel-grass from Ipswich Bay. The situation remained much the same in 1938 and 1940. At no time were large or disease-free colonies found, although the eel-grass was returning slowly. Most of the plants, except seedlings, were brownish and stunted and had many leaves broken off at various levels. Some of the fragments dredged and found floating were green and healthy in appearance, but there was not enough healthy stock to effect a significant recovery of the species. Apparently most of the plants were growing from old rhizomes, as found by Renn (1936b, 1937) in other localities. The general situation between 1933 and 1940 was similar to that reported by others for various sections of the Atlantic Coast.

ECOLOGICAL SIGNIFICANCE

With the virtual disappearance of the eel-grass, an entire biotic unit, the Zostera association or Zosteretum, was eliminated. Stauffer (1937) studied the effect on invertebrate populations which formerly inhabited eel-grass beds in the Woods Hole region; a third of the species declined, many disappeared, and others moved to the mud flats. The writer has observed that some members of the former Zostera community survived by living on algae, particularly on *Laminaria* sp.; others failed to survive.

The absence of eel-grass on shallow subtidal bottoms resulted in many bare areas; these were observed from a diving helmet and also at extreme low tides. How the rate and type of sedimentation will change in the absence of eel-grass is not yet known. Rather frequent dredgings formerly were necessary to keep an 8-foot channel for navigation in the inlet, eel-grass having been instrumental in the silting process.

One of the most significant indirect effects has been the elimination of a source of detritus. Studies on the local marine communities showed that de-

tritus is probably the most important single item at the base of the food chain of the intertidal and shallow subtidal communities. It is well known that *Zostera* contributed much sea-wrack at the drift line where it was broken down into detritus. The windrows of sea-wrack also were a habitat for many small animals.

Cottam (1934a, b; 1943) has pointed out the loss of duck food and the serious situation, particularly for sea brant, that depended largely upon eel-grass or its associated animal life for food. Disappearance of this plant also meant the elimination of feeding and breeding grounds for certain fishes. Shortly after the eel-grass disappeared at Cape Ann, the population of the soft-shell clam (*Mya arenaria*) declined quickly, until in 1934 the clams were scarce and the clam industry was practically non-existent. It is believed that without eel-grass beds to slow the currents and hold back the clam "seed," most of the latter is washed into deep water. It became necessary for the State Department of Fisheries to sow seed-clams on many flats of the Massachusetts coast to restore the population. After 1934 the clams gradually returned. The razor clam (*Ensis directus*) suffered a similar but less pronounced decline. Cottam (1934a) records a similar scarcity of shellfish food at Muskeget Island, Massachusetts, during the eel-grass decline of 1894. Dreyer and Castle (1941) reported on the decrease of the scallop (*Pecten irradians*) at Long Island and of its return there as the eel-grass began to reappear. At Cape Ann the writer observed that a small snail (*Lacuna vincta*) characteristically on eel-grass, continued on *Laminaria* spp., but after 1934 the snail suffered a drastic decline in abundance for two years; by 1937 it was slowly increasing.

The lobster industry was depleted at the same time as the clam industry. Lobsters (*Homarus americanus*) decreased to such low numbers that the setting of traps no longer was profitable in most sections of Cape Ann, especially in the Annisquam inlet. A small mud crab (*Neopanopeus*) was common until 1933; it was rarely found in 1934, was not collected in 1935, and then small numbers gradually appeared in 1936–37.

Cottam, in several papers, has outlined the economic uses made of the eel-grass itself, and the losses sustained by that industry. Another human relationship not mentioned previously, and of positive value, has been the removal of a source of danger to swimmers. At Cape Ann alone, several drownings had earlier resulted when swimmers became enmeshed in beds of eel-grass and were unable to extricate themselves.

SUMMARY

Zostera marina disappeared at Cape Ann, Massachusetts, in 1932, then returned in small isolated clumps and a few seedlings were produced. Between 1933 and 1940 the colonies increased yearly, growing chiefly from old rhizomes; most of the plants were diseased, and neither survived for long nor led to a significant return of the species.

The disappearance of eel-grass disrupted an entire biotic community, removing a direct source of food for some aquatic birds and fishes, and indirectly affected many marine invertebrates, which in turn serve as food for other animals. Bare areas were created on shallow subtidal bottoms, and an agent

in sedimentation and in the retention of shellfish was eliminated. Certain animals declined in abundance or disappeared entirely. The clam and lobster industries suffered severe losses. Only one advantage has been gained—that of removing a hazard to swimmers.

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WILD RICE IN MINNESOTA

John B. Moyle

Bureau of Fisheries Research, Minnesota Department of Conservation, St. Paul, Minnesota

Wild rice (*Zizania aquatica*) is an aquatic grass of the Tribe Zizanieae which produces grain valued as food for waterfowl and as a table delicacy for mankind. It is a native plant and not the ancestor of the cultivated rice of commerce. Wild rice grows throughout the eastern half of the United States and adjoining portions of Canada (Hitchcock, 1935), but is more abundant in central and northern Minnesota than in other parts of its range. Minnesota wild rice stands are autumn feeding grounds for waterfowl on the Mississippi flyway. Martin and Uhler (1939) report that this rice formed 5.10 per cent of the food in the stomachs of many game ducks taken in the eastern United States, and Morse (1941) found it made more than 50 per cent of the food for wild ducks on some Minnesota lakes in autumn. Wild rice has long been gathered for food by the Minnesota Indians and at present is harvested in considerable amounts by both Indians and whites.

Ecology of Wild Rice

Wild rice grows in shallow lakes and along streams in water 1 to 3 feet deep. The seeds, buried in the bottom mud since the preceding autumn, germinate in May and June to produce ribbon-like submerged leaves. By late June and July these leaves have grown to float on the water surface. The blossom stalks emerge during the first 2 weeks in July, and when a few inches above the surface begin to flower; the stalks continue to grow until the grains are nearly mature. At the time of ripening, in late August and September, the "straw" extends 2 to 8 feet above the water. Each stalk produces a terminal panicle of unisexual spikelets—pistillate on the upper ascending branches and staminate on the lower spreading branches. The pistillate portion matures from the top downward and about 10 days are required for the ripening of all the seeds. Around each kernel is a hull of the persistent palea and awned lemma. When fully mature, the entire spikelet disarticulates from the pedicle, drops into the water, and settles into the bottom mud. Most wild rice plants have but one stalk with a terminal panicle or "head," but stooling may occur in shallow water when an individual plant will produce five or six stalks.

Wild rice usually grows in nearly pure stands. The lakes producing this crop show marked seasonal differences: in spring they are expanses of open water, in midsummer covered with a mat of floating leaves, and in late August and September resemble fields of cultivated grain. The vegetational complex of wild rice stands is essentially one of annual development. The aquatic plants usually associated with this grass begin growth each season from seeds, winter buds, or other types of propagules. Rooted perennials are uncommon. In Minnesota the most common aquatics associated with wild rice are bushy pondweed (*Najas flexilis*), coontail (*Ceratophyllum demersum*), duckweeds

(*Lemna minor*, *L. trisulca* and *Spirodela polyrhiza*), bladderwort (*Utricularia macrorhiza*), and a pondweed (*Potamogeton zosteriformis*). The bushy pondweed is especially abundant in some stands and, like the wild rice itself, is avidly eaten by waterfowl (Morse, 1941).

In Minnesota, the chemical nature of the water seems to be the principal factor affecting the natural distribution of wild rice. This crop tolerates the entire carbonate (total alkalinity) range of Minnesota waters (5 to 250 p.p.m.), but is intolerant of sulphates. No large stands of rice occur in waters having a SO_4 content greater than 10 p.p.m., and rice generally is absent from water with more than 50 p.p.m. Best growth is made in carbonate waters having total alkalinity greater than 40 p.p.m. Most Minnesota wild rice stands are on mucky soils over gravel or sand. The crop grows best in lakes having some water moving through and often is lacking from stagnant lakes and pools, especially bog lakes with dark brown water. It is frequent along streams and at lake inlets and outlets.

THE CROP AND ITS HARVEST

Surveys in 1940–42 showed at least 15,000 acres of wild rice in stands of 5 acres or more; the total probably would approach 30,000 acres if all smaller stands were considered. The stands vary from small patches fringing lakes and creeks to nearly 1,000 acres in some large shallow lakes; about 150 are large enough to warrant harvesting. The principal stands of more than 500 acres each are in Nett Lake, Koochiching County; Upper and Lower Rice lakes, Clearwater County; Star Lake, Otter-tail County; Lake Minnewawa, Aitkin County; and Big Rice Lake, Cass County.

The Minnesota harvest (calculated from returns by about 10 per cent of the harvesters), was 1,586,000 pounds, or 793 tons of parched or processed grain, in the bumper crop of 1940. In 1941 only 20,000 pounds were taken but in 1942 the harvest was 337,000 pounds, about 75 per cent of normal (estimated annual production of processed rice about 500,000 pounds). The poundage of non-processed grain was 2.5 times the foregoing figures. In 1940, 2,500 persons were engaged in the harvest. In most years the grain has a gross sales value between $100,000 and $400,000. The price paid on the stands for non-processed rice in 1940 to 1943, was 5 to 12 cents a pound. During the same period processed rice brought 20 to 40 cents a pound on the stands and retailed in Minnesota at 40 to 60 cents per pound. In addition to the processed rice sold for table use, considerable amounts of non-processed grain are purchased by aquatic nurseries and sold to sportsmen for planting as a waterfowl attraction.

HISTORY OF RICE HARVEST

Wild rice has long been harvested by the Minnesota Indians and prior to the coming of the white man was one of their staple foods. Before 1800, most of the stands were controlled by the Sioux; the Chippewas, now the bulk of the state's Indian population, then inhabited only the north shore of Lake Superior. The earlier and more general use of firearms by the Chippewas and the pressure of white settlement on both tribes, allowed the Chippewas to gain control of most of the wild rice be-

tween 1820 and 1860. Later these Indians were settled on reservations, most of which included or were close to the more important rice stands, and until recent years they have harvested most of the grain. At present, about one-third of the licensed harvesters are of Indian blood. In 1888 it was estimated that wild rice comprised a quarter of the food of the Winnibigoshish, Cass, and Leech Lake Chippewa bands (U. S. Supreme Court Transcript, 1922, p. 160). Estimates of the harvest between 1861 and 1909 by Indian agents (Jenks, 1898; Winchell, 1911) suggest that probably not more than 6,000 or 7,000 bushels were harvested each year by the Indians and in most years the harvest was considerably less. At least twice as much wild rice probably now is harvested annually as was taken formerly by the Indians.

HARVESTING AND PROCESSING

The primitive Indian method of harvesting, as related by Jenks (1898) and as described to the writer by older Chippewas, involved sheaving or tying the standing heads. The standing sheaves then remained on rice beds until all of the kernels matured. The harvester then would pole through the stand, bend the sheaves over the edge of the canoe, untie the heads, and knock off the grains with a short flail. When a boatload was gathered, it was taken ashore, spread on blankets for a day or two to dry, and then heated and stirred in a large iron kettle until the hulls were brown and brittle. Often the heating was continued until most of the grains were popped. This heating process is called parching. Threshing was accomplished by dancing on or beating the grains with poles until the parched hulls were loosened. The grain was then separated from the hulls by winnowing. In recent years, binding the heads into sheaves has been abandoned, both because of the labor involved and of the ease with which such rice can be pilfered by less industrious harvesters. Rice now is harvested by poling a narrow flat-bottomed boat through the ripening stand and knocking the ripe grains into the boat. Harvesting is generally a family affair. The man usually stands in the rear to shove the push-pole and the woman, seated in the middle, gathers armfuls of the stalks with aid of a tapered stick 2 to 3 feet long, bends the heads over the edge of the boat, and taps them lightly with a similar stick to remove the ripened grain. Since the heads ripen over a 10-day period and the kernels fall as they ripen, each stand must be harvested several times to get even a small percentage of the crop. Stands usually are harvested four times at 2-day intervals.

The primitive processing now is used by only a few of the older Indians. Most of the rice is processed with simple homemade machines. A common device for parching consists of a steel oil barrel rotated over a low wood fire on a central iron shaft through the barrel that terminates in a crank. Threshing is done with another barrel fixed horizontally on a platform; centered in this barrel is a revolving shaft carrying eccentric paddles shod with pieces of old automobile tire casing. On the end of the shaft is a pulley, belted to a gasoline engine or to the rear wheel of a jacked-up automobile. The hulls are removed as the grains are thrown back and forth against the paddles. An ordinary farm

fanning mill is commonly used for winnowing. In the larger ricing camps there usually is a division of labor and certain individuals spend most of their time at processing the grain.

Much of the wild rice now harvested is sold to commercial processers as it comes from the stands. These firms have developed better mechanical means for processing the grain and can produce a more uniform finished article. The rice usually is heated only until the hulls are brittle enough to thresh and the grains not popped, as often occurs in hand processing. Popped grains tend to fragment and make a less attractive product. Machines for harvesting wild rice have been devised but are no longer allowed on Minnesota stands because the harvesting is being maintained as a self-perpetuating hand industry. A harvester used with some success is a flat-bottomed motorboat with a mechanically-operated reel on the front, similar to that of a grain binder, to knock the grains from the heads into the boat.

VARIABILITY OF WILD RICE

Two kinds of wild rice have long been recognized by plant taxonomists: a tall, robust, wide-leafed type (*Zizania aquatica*) and a shorter, narrow-leafed rice *Z. aquatica* var. *angustifolia* (Hitchcock, 1935). In Minnesota stands much of the material appears to be intermediate, although both varieties can be found. Plants fitting both descriptions frequently occur in a single stand. In general, var. *angustifolia* is commoner in the softer waters of northeastern Minnesota (total alkalinity less than 50 p.p.m.) and the taller *Zizania aquatica* is more characteristic of the harder waters of the southern and western parts of the wild rice area.

Distinct strains of wild rice occur in many Minnesota beds, and an experienced buyer often can tell from a sample of grain the stand which produced it. Detailed examination of the more important stands in 1940, 1941, and 1942 showed them to differ markedly in the average size and number of kernels per head, and these characteristics were fairly constant from year to year. This is generally recognized by harvesters of wild rice and some areas, such as Nett Lake and Lake Minnewawa, have long been famous for the large kernels produced.

The length of the kernel or spikelet, from base of spikelet to base of awn, commonly varies from 6 to 20 mm. The averages, for length of kernel, from 85 stands were as follows:

Average length, millimeters	*Number of stands*
8	2
9	3
10	2
11	9
12	10
13	14
14	14
15	18
16	5
17	1
18	7

The average length of kernels for all stands was 13.6 mm. Strains with kernels 15 to 18 mm. long are sold by aquatic nurseries as "giant wild rice," and those shorter than 10 mm. are known as "bird or river rice." The average number of kernels per head was 15 to 212 on the 50 stands examined:

Average kernels per head	*Number of stands*
15 to 50	17
51 to 100	18
101 to 150	14
151 or more	1

The grains and grain scars on a dozen or more typical heads from each stand were counted. The leaves varied from

under 10 mm. to about 30 mm. in width. Variation also occurs in the length of awn and color of the heads. Most maturing heads are green but nearly every stand has a sprinkling of purplish heads; the grain produced by the two color phases, however, is identical. The height of mature stands above the water surface was 2 to 8 feet.

Different stands exhibited nearly every combination of these variable characteristics, but the shorter, narrow-leafed rice generally produces fewer and larger grains than the taller, wide-leafed type. All stands producing grains that averaged 18 mm. in length had panicles with fewer than 50 kernels and had or approached the growth form of var. *angustifolia*. This type is most valued by the harvester because the large grains and short straw facilitate harvesting from a boat.

There is considerable variation in the number of days required to mature the crop. The first stands begin to ripen about August 18 and the last about September 12; most of them begin between August 24 and September 3, the greatest number usually ripening about September 5. Since about 10 days are required to complete the ripening, most of the harvesting occurs between August 25 and September 12. Ripening dates are fairly constant and do not vary more than 2 or 3 days in any stand over a period of years. The first to ripen has both short straw and small grains; the taller rice and that with more grains per head, generally is later.

The most distinct strains are found either in small isolated stands or in the large continuous stands of the general rice area; their natural development may be attributed to self-pollination over a long period of years. The age of most Minnesota stands is not known, but harvesting has been carried on regularly in some large beds for at least 100 years.

CROP FLUCTUATIONS AND FAILURES

On the basis of harvest data for 24 years at Nett Lake in Koochiching County, for 21 years at Platte and Sullivan lakes in Morrison County, and for shorter periods on other waters,[1] the harvest during any 4 years is likely to fail once, and to produce one bumper and two fair crops. Jenks (1898) gathered considerable evidence on harvest failures and reached the same conclusion as to their frequency. Failure results mainly from high water during June and July. The best crops occur in years of sub-normal rainfall with receding water levels. Comparison of the water levels in 1940 (bumper crop) and in 1941 (poor crop) shows that a water stage 12 inches or more above normal during the period from May 15 to July 1 caused a failure and a stage 6 inches above normal reduced the harvest on some stands by more than half. Lake Minnewawa, Aitkin County, had a water stage 6 to 8 inches higher in 1941 than in 1940 and suffered a reduction in harvest from 60 tons to less than one ton.[2] Continued high water when the plants have only submerged leaves results in such weak, attentuated growth that the plants are easily destroyed by

[1] Data for Nett Lake from memorandum by S. D. Walker to M. L. Burns, Acting Superintendent, Consolidated Chippewa Agency, Cass Lake, Minnesota, Sept. 15, 1939. Data for Platte and Sullivan Lake from Walter Zak, Hillman, Minnesota (letter, Dec. 29, 1941).

[2] William Simpson (letter Sept. 11, 1941) to the Division of Drainage and Waters, Minnesota Department of Conservation.

wave action and adverse weather (Chambliss, 1940). This phenomenon is locally known as "drowning." Heavy wind, hail, and rain storms while the kernels are maturing also bring about failure or reduction of the harvest by lodging and uprooting the plants.

In some years many of the rice flowers do not set grains. The cause is unknown but usually is attributed to hot, dry weather when the plants are in flower. Eleven of the 14 stands observed in detail during 1941 produced heads on which less than 50 per cent of the spikelets matured. Rice harvested from such stands is light in weight and the sterile grains must be removed by water flotation before it can be processed.

The army worm (*Agrotis* sp.) occasionally destroys limited amounts of wild rice near shores by feeding on the maturing grains, and a few grains sometimes are infected with ergot. Stands in southern Minnesota have been destroyed by German carp, and muskrats frequently gnaw off the stems at the waterline.

YIELD AND HARVEST

In 1941 an estimate of the total yield was made on 14 stands. Two to 11 representative sample areas were selected on each and delimited by floating wooden hoops, each enclosing an area of 11.5 square feet. The number of areas sampled depended upon the size and the uniformity of the stand. On each area, all panicles were removed and bagged for study. To obtain the total yield per unit area, the following data were obtained from these collections: (1) the average number of panicles per square foot, (2) average number of grains and grain scars per panicle, (3) average weight of dry grain per square foot, and (4) percentage of sterile spikelets. The 1941 harvest on most stands was regarded as a failure, but all 14 stands produced some rice and averaged 168 (50 to 401) pounds of processed rice per acre.

All these stands were open to harvesting but only two were harvested: Upper Rice Lake in Clearwater County with a total production of 401 pounds per acre, and Big Rice Lake in Cass County with 323 pounds per acre. Harvesting was attempted on some others but abandoned. It seems, therefore, that unless a stand produces more than 300 pounds of processed rice (or 750 pounds nonprocessed) per acre, hand harvesting is not profitable.

The long record of harvest data for Nett Lake showed the harvest there has varied from 6 to 43 tons, averaging about 15 tons. The stand usually comprises about 800 acres of harvestable rice and has, therefore, an average yield of 37.5 pounds per acre. In contrast, the total production in 1941 (poor crop) was 185 pounds. A crude estimate of the average on all stands can be gained by dividing the average annual take per licensed harvester by the number of acres allotted to him for harvesting. The average allotment is about 10 acres; the average take for 1940 was 393 pounds and for 1942 was 315 pounds. This suggests the usual amount taken as between 30 and 40 pounds of processed rice per acre. Stewart (1926) carefully checked the harvest on a 2,000 acre Minnesota stand and found 50 pounds of processed rice per acre taken in 1924, a good crop year.

Several factors are involved in the marked difference between total yield

and total harvest; most important are incomplete harvesting of individual heads by hand methods and incomplete coverage of the stands by the harvesters. Since several of the best Minnesota stands are known to have been harvested by hand for at least a century, it is evident that such harvesting does no damage to them and leaves most of the grain for waterfowl and reseeding.

PROPAGATION OF WILD RICE

Because of its obvious value as an attraction for waterfowl, wild rice has been planted in many waters where it did not occur naturally. Some plantings have succeeded, but more have failed. Of eight made in the wild rice area of northern Minnesota during 1940, four produced good crops, three fair crops, and one failed the following year. Three other plantings during 1940 in waters high in sulphates failed completely. Two earlier seedings in the wild rice area produced fair crops the first year but failed thereafter. Miller (1943) examined the results of 50 plantings of wild rice in Michigan and found that 74 per cent of them failed to become permanent.

The conditions that appear most conducive to success of wild rice in Minnesota are: (1) clear water, 1 to 3 feet deep, with total alkalinity greater than 40 p.p.m. and SO_4 concentration less than 10 p.p.m.; (2) organic soil 6 inches or more in depth, preferably with some calcareous material such as snail shells; (3) some movement of water through the area; (4) fluctuation of water level less than 6 inches throughout the growing season; and (5) absence of carp. Almost all such waters within the wild rice area now have rice, and planting is usually advisable only when stands have been destroyed by drought or a long period of fluctuating water levels.

Since wild rice is available as waterfowl food only for about a month and provides good shelter for only about 2 months each year, it is less desirable as a food species than the pondweeds (*Potamogeton*) and less desirable for cover than the perennial bulrushes (*Scirpus*). It does, however, provide much excellent food during the autumn waterfowl migration and therefore is one of the most effective aquatic plants to attract and concentrate waterfowl.

Wild rice seed should be kept cool and moist from the time it is harvested until planted; two methods of storage have been found to be effective. It can be stored in double burlap sacks encased in cages of chicken wire and submerged in a lake; the wire excludes muskrats, which have a great liking for the seed. Seed also can be stored in a cool root cellar in double burlap sacks, so arranged that water from melting ice will drip upon the sacks continuously and keep the seed moist.

Planting is best done from a boat or canoe. The seed should be scattered over the surface of waters that are 1 to 3 feet deep in depth. All good seeds will sink to the bottom immediately. The best rate for seeding is about 1 bushel per acre or, in small areas, a large handful to an area 6 by 6 feet. Preferably, plantings should be made a short time before ice forms in fall or as soon as the ice breaks up in spring.

SUMMARY

Minnesota contains more than 15,000 acres of wild rice (*Zizania aquatica*) growing in shallow lakes and along

streams in the northern and central parts of the state. This native, unimproved grain exhibits considerable variation in the size and number of kernels per head and in other characteristics, and it tends to develop local strains.

The crop, in addition to having value for waterfowl, provides an average annual harvest of about 500,000 pounds of processed rice. Up to 2,500 persons, about one-third of Indian blood, engage annually in the harvesting and the grain usually has an annual value of $100,000 to $400,000. The grain is harvested by hand methods similar to those long used by the Minnesota Indians. Simple mechanical procedures have now largely replaced hand labor for parching the grain and removing the hulls.

On any stand the harvest will fail, on the average, one year in four, the principal cause being a high water level during May and June. Sufficient grain for reseeding usually is produced in years of harvest failure.

The few data available suggest that often as little as one tenth of the crop on a stand is taken by hand harvesting leaving most of the grain for waterfowl and reseeding. When total production, calculated as processed rice, is below 300 pounds per acre, hand harvesting usually is unprofitable. The average harvest in Minnesota is about 30 to 40 pounds per acre (processed rice).

Wild rice, is more of an attraction than a staple food plant for waterfowl, and shows marked preference for certain habitat conditions; unless these conditions are supplied plantings are apt to fail.

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SURVIVAL AND GROWTH OF SHRUBS PLANTED FOR WILDLIFE IN NEW YORK[1]

David B. Cook and Frank C. Edminster

State Conservation Department, Albany, New York, and U. S. Soil Conservation Service, Upper Darby, Pennsylvania

The ability to control plant cover is a basic requirement for successful wildlife management. Such control implies not only the power to maintain cover types already in occupancy, but to replace one type with another at reasonable cost and with certainty of results. Based on long experience, in both the United States and Europe, there have been developed satisfactory techniques for planting the hardier softwood species. The site requirements of the more exacting hardwoods, especially food-bearing trees and shrubs necessary for development of good wildlife habitats, are imperfectly understood.

Some of the most serious wildlife management problems are presented by 3,000,000 acres of abandoned farmland scattered through the Allegheny Plateau in New York State. This is a deeply-dissected tableland west of the Hudson Valley and Catskill Mountains and south of the Mohawk Valley and Lake Ontario plain (Fig. 1). The region is underlaid by unaltered sedimentary rocks—shale, sandstone and some limestone—and the flat-bedded strata dip gently to the southwest. Much of the drainage follows the tilt of the rocks southward, into the Delaware, Susquehanna and Allegheny river systems; the remainder flows north into the Finger Lakes, Lake Ontario, and the Mohawk River. The broad, flat-topped summits seldom exceed 2,000 feet in elevation and are separated by narrow and steep-sided valleys. The soils are mostly stony loams, derived from the underlying rocks and altered by glaciation, and are acid save where modified locally by calcareous material in the subsoil or substratum. Exploitive agriculture has resulted in serious sheet erosion besides depletion of lime and nutrients, especially on the thin hilltop soils. The climate is modified continental, with long cold winters and short summers; the annual rainfall approximates 40 inches and the snowfall is moderate.

Fig. 1. The Allegheny Plateau (shaded) and the Partridge Run Game Management Area (●) in New York.

Some areas of oak-hickory forests occur in the south-central parts, but most of the Plateau is occupied by northern hardwoods; dominant trees are the hard maple (*Acer saccharum*),

[1] Contribution from Federal Aid in Wildlife Restoration, New York Project 1-Research.

beech (*Fagus grandifolia*), and hemlock (*Tsuga canadensis*). Old fields are invaded by such pioneers as aspen (*Populus tremuloides*), fire cherry (*Prunus pennsylvanica*), paper birch (*Betula papyrifera*), and white pine (*Pinus strobus*). Dogwoods (*Cornus*), viburnums (*Viburnum*), and brambles (*Rubus*) are characteristic shrubs. Old fields bear stands of timothy (*Phleum*), red-top (*Agrostis*), and poverty grass (*Danthonia*).

Since 1929, public agencies, both State and Federal, have been acquiring submarginal farmland throughout the Plateau. Administrative responsibility for most of this is now vested in the State Conservation Department. Some 60,000 acres are managed primarily for wildlife, and on an additional 300,000 acres wildlife is important as a secondary crop. Production of satisfactory crops of game on these areas dictates the conversion to brush or woods of most of the acreage (about 50%) now occupied by grass. The planting of conifers directly in sod, with no previous site treatment, usually has given satisfactory results, but the same has not been true of the more exacting hardwood trees and shrubs that provide food for wildlife. To handle such planting stock so as to ensure good survival and rapid growth, is a problem meriting careful study.

SHRUBS TESTED

In the spring of 1941, the Soil Conservation Service and the New York State Conservation Department, (through its Federal Aid in Wildlife Research Project) cooperated in establishing a shrub test to show the relation of certain site treatments to survival and subsequent growth and also the effect of size of planting stock on success of establishment. Plantings were made on the Partridge Run Game Management Area of the Conservation Department in the Town of Berne, Albany County (Fig. 1). This area is close to the eastern rim of the Allegheny Plateau and is reasonably typical of the latter. An old meadow was selected on a moderate northeast slope, on Langford gravelly silt loam. The drainage is better than on the more level hilltops and snow has been sufficiently deep and persistent to afford adequate winter protection.

Thirteen species of shrubs and trees that produce food for wildlife were selected from stock in Soil Conservation Service nurseries, as follows:

	Origin	*Standard height when planted (inches)*
Northern bayberry (*Myrica pensylvanica*)	Native	6
Thunberg barberry (*Berberis thunbergi*)	Exotic	6
Multiflora rose (*Rosa multiflora*)	Exotic	7
American mountain ash (*Sorbus americana*)	Native	8
European mountain ash (*Sorbus aucuparia*)	Exotic	8
Black chokeberry (*Aronia melanocarpa*)	Native	6
American plum (*Prunus americana*)	Native	6
Early shrub lespedeza (*Lespedeza cyrtobotrya*)	Exotic	6
Silky dogwood (*Cornus amomum*)	Native	6
Arrowwood (*Viburnum dentatum*)	Native	6
Nannyberry (*Viburnum lentago*)	Native	6
Black haw (*Viburnum prunifolium*)	Native	6
Snowberry (*Symphoricarpos albus*)	Native	8

Because of the great disturbance of the flora wrought by a century of lumbering and agriculture, we know only

approximately the original distribution of many native shrubs. Species classified as "native" are known to occur naturally within 100 miles of the planting site. Considerable data have been accumulated on field planting methods and the growing ability of 12 of the species listed (early shrub lespedeza was of unknown potentialities).

Stocks of all except snowberry were used in both standard and substandard grades. Standard stock was that which measured up to minimum height, diameter, and root-top balance standards now used by the Soil Conservation Service in the Northeast. Ordinarily, ofily plants meeting these standards are shipped from Service nurseries for field use. Cull stock was smaller, usually by 2 inches or more in height and proportionately smaller in diameter. The two were always planted in adjacent rows to minimize the effect of minor differences in site.

SITE TREATMENTS

Three site treatments were used, in bands paralleling the contours: (1) plowed and harrowed a week before planting; (2) 12-inch scalps 3 inches thick cut with a shovel and the sod laid aside; and (3) undisturbed, the plants being set directly into the sod by the modified slit method commonly used for field planting of conifers.

Plowing breaks the old sod and induces an entirely new aggregation of plants, chiefly from seed already in the ground. Competition for moisture and nutrients is much reduced for the first two or three years. Plowing improves the aeration and water-absorbing capacity of the soil, increases the available nutrients by incorporating organic matter, and permits practically full sunlight to reach the ground. After plowing, from five to eight years are required for reestablishment of a complete sod cover.

Scalping has the marked disadvantage of removing the most fertile and friable topsoil and the plants are set in relatively infertile ground. Sod competition is reduced, but the planted stock is considerably shaded by adjacent vegetation. On slopes, the plants are favored by surface runoff collecting in the scalped spots. At Partridge Run this may be of importance, because summer droughts often are severe.

In the absence of any site preparation, planted stock is subject to all the hazards of competition with well-established sod. Hardwood trees and shrubs so planted appear to have difficulty in obtaining sufficient nutrients and moisture. Tall grasses and weeds crowd and over-shadow the planted stock and their fallen stems may smother such stock.

All of the plants were set in lines at right angles to the bands of site treatment, at a uniform spacing of 3×3 feet. Each strip contained 60 plants of a single species and grade, 20 in each of the three site treatments. In all, 3,000 plants were used. The senior author supervised the planting operation and made the field measurements. Frequent observations during the vegetative seasons afforded familiarity with the growing abilities and growth habits of these species, which cannot be measured or adequately expressed in figures. At the end of each growing season, complete tallies were made of all plants as to survival and individual height. For decumbent species such as the rose, total height was recorded as the length of the longest cane. Since many of the

plants had multiple stems, total height is not an adequate measure of growing capacity, but the mechanical difficulties of the more accurate system of measuring total length of stem were so great that the added accuracy did not seem to justify the increased cost.

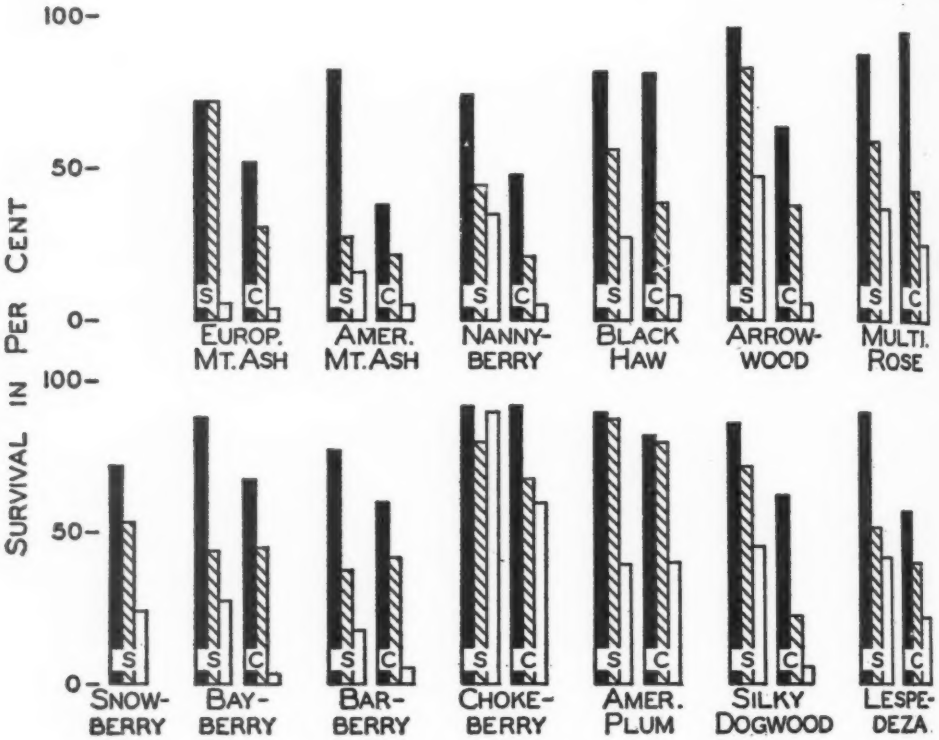

Fig. 2. Survival of shrubs. *S*, standard grade stock; *C*, cull stock; plowed (black); scalped (shaded); slit (clear areas).

RESULTS

Data taken at the end of the third growing season are presented in Figures 2 and 3. We believe that a three-year period is long enough to determine mortality resulting from transplanting and that no serious further losses from that source are to be expected. As to height increment, however, the growth pattern of many of our species is not known and some which were small after three years may simply be slow to start.

Soil Conservation Service nurseries grade their stock, and any plants that fail to meet specifications for height, diameter, and root-top balance are considered to be substandard or cull. The standard size varies with species (see righthand column of list above). To test the validity of these grading rules, parallel plantings were made with standard and cull stock of 13 species; no culls of snowberry were available. Standard stock has tended to show

better survival than substandard in our tests. This trend fails in only 5 (or 14%) of the 36 possible cases (Fig. 2); of these three were on plowed ground and two on scalps.

A survival of 70 per cent is generally considered necessary for successful establishment of a planting. On plowed ground our standard stock showed such survival for all 12 species, but only four (33%) of cull stock did so. On scalps, five of 12 (41%) among the standard stock were successful, but only one of 12 (8%) with substandard plants. Slit-planted stock showed a 70 per cent survival in only one instance, that with standard stock of chokeberry. The superior survival of standard stock is clearly shown in Figure 2.

Standard stock also tends to outgrow the culls, but the difference is not so pronounced as in survival. Growth of standard stock exceeded that of substandard in 32 of 36 cases (83%) but the differences were large only in a few species. The smallest variations were shown by the European mountain ash, bayberry, barberry, plum, lespedeza, and rose and the greatest differences by arrowwood and dogwood (Fig. 3). Plants able to survive are also able to make satisfactory growth. We believe that grading standards of the Soil Conservation Service are fully justified because of the marked superiority in survival and the lesser but real superiority in growth, especially where stock is planted on relatively poor sites.

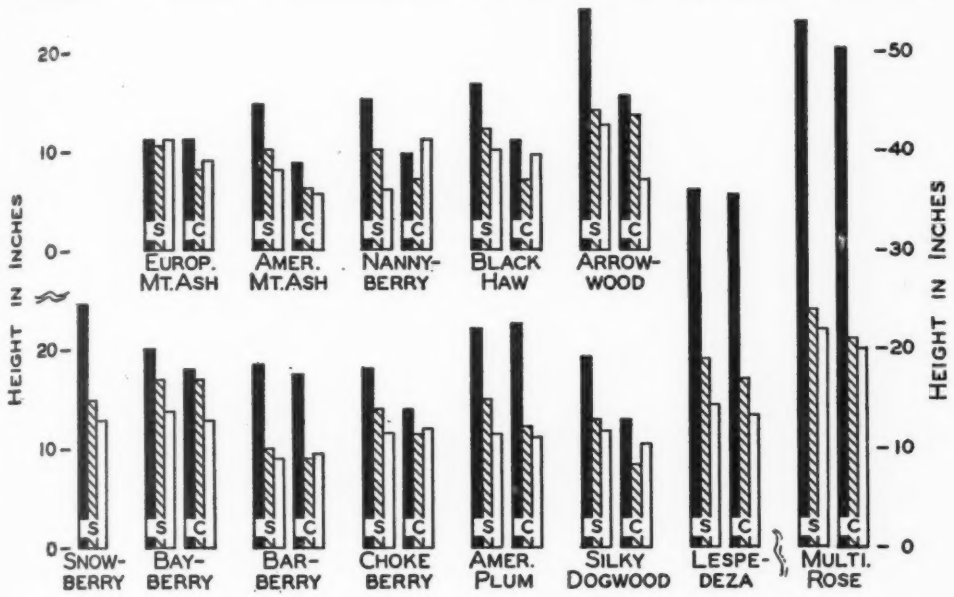

Fig. 3. Height growth of shrubs. *S*, standard grade stock; *C*, cull stock; plowed (black); scalped (shaded); slit (clear areas).

Save for the European mountain ash, the highest survival was on plowed strips, but in only one (and not the same) case did survival on scalps fail to

exceed that in slits. Of the standard stock (under the criterion of 70% survival) all 13 species were successful on plowed ground, five (38%) succeeded on scalps, and only one (7%) survived satisfactorily in slit planting. Ample field evidence indicated that high survival often is associated with poor or negligible growth and that many planted hardwood trees and shrubs will persist for years with very little height increment. Growth was best on the plowed strip (Fig. 3) with two exceptions, European mountain ash and nannyberry. The differences of response between scalps and slits were mostly small and inconsistent, but slightly favoring the scalps. In no instance could the growth of slit plantings be appraised as satisfactory and they did not offer much promise of ultimate success.

On the bases of height, growth, and survival, the plantings on plowed lands were conspicuously better than those on scalps or in slits. Many of the sites were on land under some sort of cultivation in the immediate past so that plowing and harrowing there should present no serious obstacles. It would not be necessary to plot entire planting sites, because there is ample evidence that plowed planting strips, preferably on contours and aggregating one-fifth of the total area, would be sufficient. Most of the cost of plowing would be saved by the greater facility in planting, leaving the better survival and more rapid growth as net gains. On sites subject to serious heaving, planting in plowed land may be hazardous. Scalps entail tedious and costly hand labor and the results apparently do not justify the added costs. Slit planting directly in sod shows the lowest initial cost, but the slow growth and low survival of most species indicate that the true cost per surviving plant is high.

SPECIES TESTED

Field observations of the experimental plantings indicate wide differences between the several species, even greater than shown by measurements (Figs. 2 and 3). Some details observed during the three years of growth were as follows:

Bayberry. This plant has done well and formed dense multi-stemmed plants with heavy, lustrous leaves. Results have been encouraging on all site treatments and with both classes of stock. Many of the plants have begun to produce stolons.

Barberry. Growth was best on plowed ground, but nowhere was the development of the plants satisfactory. The leaves were always small and pale, and the stems were slender. The site was not satisfactory for the species.

Rose. On plowed strips, the roses grew heavy arching canes with thick lustrous foliage, the whole forming a dense thorny thicket. On other site treatments, growth was less satisfactory, the canes being thin and the foliage small and yellow. Some plants fruited lightly during the third year. This is one of the most promising species when planted on a well-prepared site.

Mountain ashes. Both species grew feebly, scarcely maintaining their initial height; many died back to the ground and some were defoliated by sawfly larvae. They showed lack of vigor and seem poorly adapted to field planting. Survival on sod was poor.

Chokeberry. This proved to be a hardy and vigorous shrub, making good growth on all sites and with both classes

of stock. Plants began to produce stolons and to form thickets, especially on plowed ground.

American plum. The younger stages form single-stemmed plants. Good growth and survival resulted on plowed land and scalps, but only fair results occurred in slit plantings.

Early shrub lespedeza. The growth of this species was second only to that of the rose. The plants developed good height and showed excellent vigor, but often died back at the tips each year. Many flowered late in the third season after planting, about September 15.

Silky dogwood. The shrubs grew well and produced a rather open form that had considerable tendency to spread; this is one of the most promising species.

Arrowwood. Of the viburnums tested, this proved to be the best. It was hardy and vigorous in growth, capable of forming sizeable bushes in a short time, and showed little tendency to form thickets.

Nannyberry. Slender, upright, many-stemmed plants of short stature developed, being the poorest as to growth of the three viburnums tested.

Black haw. This became a stocky, blunt-twigged shrub with better growth than that of the nannyberry but scarcely satisfactory on the Allegheny Plateau.

Snowberry. On plowed ground this species produced upright vigorous plants, but survival and growth were only fair on the other sites. No cull stock was tested.

LIMITATIONS OF TESTS

The findings presented here should be applied with caution, because the site tested is one of moderate quality and not subject to excessive frost heaving. On heavy soils where heaving is serious, plowing in preparation might yield unsatisfactory results. Our plantings were made early in a dry spring season which was followed by an even drier summer. This tended to accentuate the competitive disadvantage of plants set in slits in the sod, and made those on plowed land seem proportionally better than they might have if planted in a more normal season. The relatively high fertility of the site would be more favorable to hardwoods than lighter, poorer soils. We believe that these findings can be applied to comparable sites in those parts of southern New York and northern Pennsylvania designated by the Soil Conservation Service as the "Pennsylvania-New York Border Land Resource Area."

SUMMARY

In 1941, the New York State Conservation Department and the U. S. Soil Conservation Service cooperated in field tests of 13 species of hardwood trees and shrubs. The planting site was in Albany County, at the eastern edge of the Allegheny Plateau.

Three site treatments were used: plowing the site gave the best growth and highest survival, whereas scalping proved only a little better than slit planting in undisturbed sod.

Two grades of stock, standard and cull, were tested; the former showed definite and consistent superiority.

The extra cost of plowing is more than offset by greater ease of planting and better growth and survival.

At the end of the third growing season, the most promising species were arrowwood, multiflora rose, early shrub lespedeza, silky dogwood, black chokeberry, and bayberry.

EXPERIMENTS ON TRANSFER OF ADULT SALMON INTO DEER CREEK, CALIFORNIA[1]

Lewis P. Parker and Harry A. Hanson
U. S. Fish and Wildlife Service, Stanford University, California

With the construction of Shasta Dam on the Sacramento River in northern California, the chinook salmon (*Oncorhynchus tschawytscha*) in that river were forever blocked from reaching their ancestral spawning areas above the dam. Consequently, a salvage plan was proposed whereby the salmon could be transferred to spawn in waters below the dam.[2] A part of this plan was to move the early spring run salmon to Deer Creek for natural propagation in that stream (Fig. 1). An experimental transfer was made to determine whether spring run salmon released there would distribute themselves suitably in the stream and survive to spawn naturally. A portion of the transferred fish were marked by various methods so that they could be distinguished from the native run salmon.

To avoid overstocking Deer Creek, it was necessary to determine the size of the native spring-run of salmon into that creek. From May 20 to July 6, 1941, 635 were counted through a weir located about three miles above the mouth of Deer Creek near the town of Vina in Tehama County. This total represented only part of the native run since subsequent counts showed that many salmon pass the weir site during April and early May. Survey of the riffles in this stream during 1940 indicated that there was room for approximately 4,000 nests or ample spawning space for a run of approximately 8,000 fish. Therefore, in terms of breeding areas, the transfer of approximately 1,000 fish to Deer Creek would not overcrowd the stream. On the basis of fish recovered and from counts of completed nests after spawning had ended, an estimated 6,000 native-run salmon migrated into Deer Creek during the 1941 spawning season.

Equipment

Temporary facilities for trapping and removing salmon were installed in the fish ladder of the Anderson-Cottonwood-Irrigation-District Dam on the Sacramento River at Redding (Pl. 10). The trap consisted of two metal screen barriers anchored in the uppermost pool of the fish ladder to form a chamber 7 by 9 feet. In each barrier was a central opening through which the fish could pass. The floor of the trap was a wooden slat brail that could be raised and lowered as required. When trapping was in progress, the opening in the upstream barrier was closed and fish were counted into the trap over a counting board in the lower barrier. After a sufficient number had been trapped, the hole in the lower barrier was closed. A 500-gal-

[1] This experiment was financed by the U. S. Bureau of Reclamation, supervised by the U. S. Fish and Wildlife Service, and directed by Dr. Paul R. Needham. Thad M. Blake, Norman W. Mattoon, Verl L. House, and Thomas J. Beland, aided in the transfer of fish and in subsequent observations.

[2] Hanson, H. A., Paul R. Needham and Osgood R. Smith. 1940. An investigation of fish-salvage problems in relation to Shasta Dam. U. S. Fish and Wildlife Service Special Scientific Report No. 10. (Mimeo.)

lon loading tank then was lowered into the fish ladder at the upstrea[illegible] face of the upper barrier, with the o[illegible]ning in the loading tank facing the opening in their relative sizes. The loaded tank then was lifted from the ladder to a waiting truck and the fish were released through a trap door in the bottom of

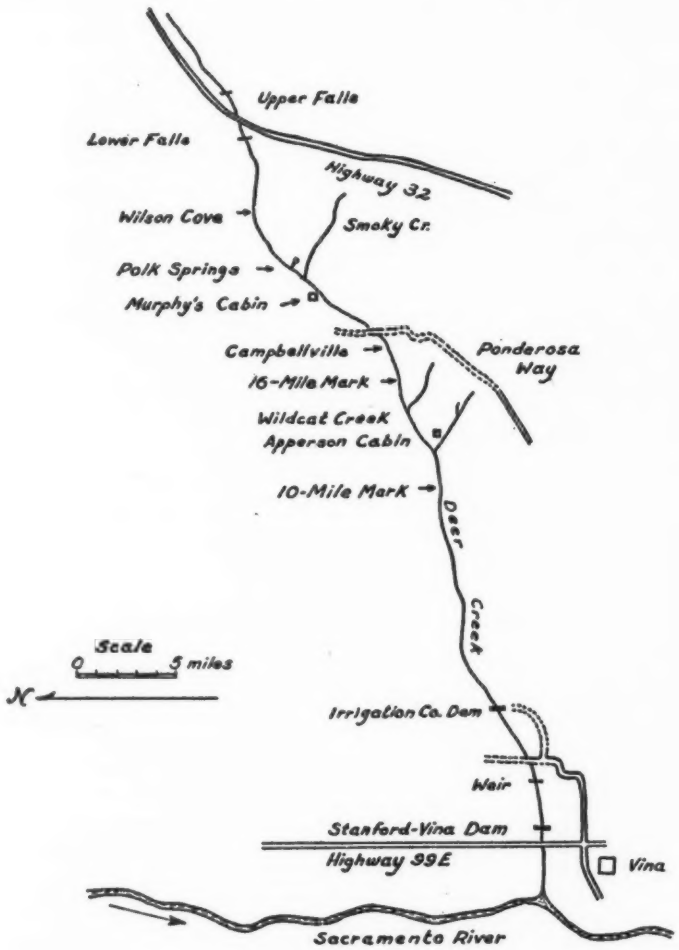

Fig. 1. Map of Deer Creek, Tehama County, California, into which salmon were transferred.

the barrier. The brail bottom of the trap was lifted, forcing the fish to swim into the tank. From 11 to 49 salmon comprised a "load," depending on the number available in the ladder and the loading tank (Pl. 11). The 65-mile trip to Deer Creek required about two hours.

The salmon were placed in Deer Creek above the counting weir previ-

ously mentioned. The truck was backed down close to the stream and the salmon were released through a pipe which led from the tank truck to a holding box anchored in the creek. If the fish were to be marked, they were dumped into a holding box; otherwise, they were released directly into the stream (Pl. 11).

placed around the caudal peduncle. This method proved unsatisfactory and was discontinued; the rubber band either fell off when the fish was released or caused serious injury to the caudal peduncle if it remained in place. Of the remaining salmon, 245 were marked by clipping off the adipose fin and 179 by removing part of the dorsal fin.

TABLE 1.—DATA ON CHINOOK SALMON TRANSFERRED TO DEER CREEK IN JUNE, 1941.

Date	Number of fish	Tank temperature (°F) At arrival	Tank temperature (°F) On release	Stream temp. °F	Oxygen content (p.p.m.) Tank	Oxygen content (p.p.m.) Stream	pH Tank	pH Stream
June								
3	20	53	62	64	10.2	—	—	—
4	11	54	64	66	10.2	—	—	—
5	36	53	65	68	9.0	8.2	—	—
6	34	54.5	64.5	67	9.3	9.2	7.2	—
6	27	55	58	60	10.5	9.9	7.0	—
7	29	55	66	68	9.6	8.7	7.2	—
9	13	55	62	65	10.0	8.9	6.6	—
10	12	60	72	74	10.2	8.3	7.2	—
11	49	57	72	74	8.7	8.5	6.6	7.4
11	48	58	70	72	8.4	8.3	6.6	7.4
12	33	58	76	78	—	—	6.8	7.3
13	36	58	76	79	10.2	8.6	6.7	7.5
14	47	58	74	76	9.0	8.0	6.6	7.6
15	40	56	73	75	8.1	8.2	6.6	6.2
16	43	58	68	69	9.1	8.7	6.7	7.5
16	44	57	65	67	9.1	8.9	6.6	7.2
17	40	56	70	72	8.3	8.5	6.5	7.0
18	23	56	69	73	9.6	8.3	6.9	7.5
19	31	56	72	74	4.8	8.4	6.7	7.2
20	41	57	67	69	9.6	8.5	6.7	7.3
21	12	55	70	72	7.8		7.1	7.5
22	30	59	67	70	10.1	8.7	6.8	7.5
23	24	52	70	73	9.9	8.4	6.8	7.0
24	34	53	66	68	9.5	9.3	6.8	7.3
25	20	55	68	70	9.3	8.8	6.9	7.3
26	20	54	70	72	9.3	8.8	6.9	7.3
27	35	56	71	73	9.4	7.0	6.8	7.5
28	29	56	71	74	9.8	8.5	—	7.5
29	27	58	74	77	9.3	8.2	—	7.5
30	32	60	77	79	8.5	8.0	6.9	7.2

METHODS

A total of 920 salmon were transferred to Deer Creek from June 3 to 30, 1941 (Table 1) and 488 of these were marked. On the first 64, the adipose fin was clipped and a red rubber band was

Salmon marked on the dorsal fin were anesthetized according to a procedure suggested by Dr. F. F. Fish of the U. S. Fish and Wildlife Service. Water in the tank truck was lowered to a depth of 25 inches and to it were added 340 ml. (11.5 fluid ounces) of concentrated sul-

furic acid diluted in 50 gallons of water. Then a solution of 3¾ pounds of sodium bicarbonate dissolved in 10 gallons of water was introduced. The carbon dioxide evolved from this reaction rendered the salmon insensible in about 1½ minutes. Clipping of the dorsal fin was done while they were in this condition, and immediately after clipping they were released into the stream. Their movements were so violent that many were injured as they regained consciousness in the warm creek water (68° to 79°F.), and 68 had died by the end of June. Sixteen more of them were found dead by the end of August and the mortality was believed to be actually greater since that part of the creek between the point of release and the dam of the Deer Creek Irrigation Company (Fig. 1) has a labyrinth of side channels making it virtually impossible to see and recover all the dead fish.

The total recovery of dead salmon by the end of August was 284 (Table 2). These included the 84 anesthetized fish previously mentioned, 62 with clipped adipose fins, and 138 unmarked. The last were believed to be transferred fish as most of them were found during or shortly after the transfers. When the first spawning activity was noted in late August, there may have been 247 fish with clipped adipose fins, 95 with clipped dorsal fins, and 294 unmarked salmon, or a total of 636 still alive of the 920 transferred to Deer Creek.

PRESPAWNING OBSERVATIONS

Weekly trips were made up the canyon from the Deer Creek Irrigation Company Dam to Campbellville from July 10 until after the first week of September to observe the movements of marked salmon and to recover and examine all dead fish.

Because of the poor visibility and of the tendency of the salmon to remain in deep pools, no marked fish were seen during the summer. Only four dead individuals were recovered in the canyon above the dam prior to spawning; two were unmarked and the others were too badly decomposed to determine whether they had been marked.

SPAWNING

The first activity preparatory to spawning was observed during the last week in August near the Lower Falls. It consisted of spasmodic attempts at nest building and periodic movements of the salmon from the deep holes onto the spawning riffles. No intensive nest building was observed there until the first week in September. In the Campbellville section nest building began at the close of the first week in September. In the Apperson Ranch section another week passed before any activity was noted. Below the Apperson Ranch section no nest building was observed until the first week in October and then only after the water temperatures had dropped sufficiently to match those found in the sections farther up stream.

RECOVERY OF MARKED SALMON

The creek was examined daily throughout the spawning season (September 10 to October 25). All dead salmon that could be recovered were examined and disposed of on land; by the end of the spawning season, 1,463 had been recovered and examined (Table 3). Of these 76 (about 5%) were too badly decomposed at the time of recovery to yield data. The greatest number of

TABLE 2.—NUMBERS, MARKING RECORDS, AND PRESPAWNING MORTALITY OF SALMON TRANSFERRED TO DEER CREEK, 1941.

Date	Number transferred	Marking		Mortality			Totals
		Clipped adipose fin	Clipped dorsal fin	Clipped adipose fin	Clipped dorsal fin	Unmarked fish	
June 1	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—
3	20	—	—	—	—	—	—
4	11	—	—	—	—	—	—
5	36	36[a]	—	1	—	—	1
6	61	—	—	—	—	—	—
7	29	28[a]	—		—	1	1
8	—	—	—	—	—	—	—
9	13	13	—	—	—	—	—
10	12	—	—	—	—	3	3
11	97	49	—	16	—	1	17
12	33	18	—	3	—	—	3
13	36	—	—	1	—	18	19
14	47	47	—	4	—	15	19
15	40	—	—	2	—	2	4
16	87	43	—	2	—	1	3
17	40	40	—	1	—	1	2
18	23	—	—	2	—	—	2
19	31	—	—	2	—	24[b]	26
20	41	—	—	2	—	—	2
21	12	—	12	—	—	1	1
22	30	—	—	1	—	29[b]	30
23	24	—	24	—	7	1	8
24	34	—	33	2	4	1	7
25	20	—	20	1	12	2	15
26	20	—	20	—	4	—	4
27	35	—	—	—	2	2	4
28	29	—	28	3	8	2	13
29	27	—	13	—	13	14	27
30	32	—	29	2	18		20
Sub-totals	920	309	179	45	68	118	231
July 1				3	—	1	4
2				—	1	1	2
3				—	1	2	3
4				—	1	—	1
5				1	1	—	2
6				1	5	2	8
7							
8				—	—	1	1
9				4	4	—	8
10							
11							
12				2	1	4	7
13				—	1	2	3
14				2	—	2	4
15–31				3	1	5	9
Aug. 29				1	—	—	1
Grand totals	920	309	179	63	84	138	285

[a] Also tagged with red band around caudal peduncle. [b] Killed in transit.

Left. Brailing salmon from trap in fish ladder (foreground) into loading tank at Redding. Brail bottom of trap was lifted by winch extending across behind fine-meshed screen. *Right.* Fish counting weir across Deer Creek. Observer's seat at center, over downstream side; overhead cable and power plant housed on opposite bank serve to remove steel framework sections of weir during highwater stages of creek. (Photos by U. S. Bureau of Reclamation.)

TABLE 3.—SALMON RECOVERED AFTER SPAWNING IN DEER CREEK, SEPTEMBER 12 TO OCTOBER 24, 1941.

Stream section	Males		Females		De-composed	Totals
	Totals	Marked	Totals	Marked		
Lower Falls to Wilson Cove	209		159	1	16	385
Wilson Cove to Polk Springs	174		114	1	7	296
Polk Springs to Murphy's Cabin	125		93		40	258
Murphy's Cabin to 16-Mile Mark	238	1	120	4	11	374
16-Mile Mark to Upper Dam	110	6	32		2	150
Totals	856	7	518	6	76	1,463

TABLE 4.—DATA ON MARKED SALMON RECOVERED FROM DEER CREEK, FOLLOWING SPAWNING IN 1941.[a]

Date of recovery	Place of recovery	Standard length (cm.) and sex	Condition of gonads
Sept.			
17	¾ mile above Campbellville	61.0, ♀	147 eggs left
18	½ mile below Campbellville	55.8, ♀	About 1,000 eggs left
18	½ mile below Campbellville	38.1, ♂	Spent
18	½ mile below Campbellville	62.0, ♀	123 eggs left
24	¾ mile below 16-Mile Mark	59.0, ♂	Spent
Oct.			
4	Wildcat Creek	48.3, ♂	Spent
4	1¼ miles below Lower Falls	67.2, ♀	11 eggs left
5	¼ mile above Steamboat Mt.	50.8, ♂	Partly spent
8	1¾ miles below Wilson Cove	71.1, ♀	Spawned out
22	1½ miles above Campbellville	67.2, ♀	6 eggs left
23	¼ mile below 16-Mile Mark	55.9, ♂	Spent
23	½ mile above Appersons	77.5, ♂	Spent
24	Deer Creek Irr. Co. Dam	66.0, ♂	Spent

[a] All marked salmon recovered had clipped adipose fins.

dead individuals was taken in the section from Campbellville to the Lower Falls. This was to be expected, as large concentrations of salmon had been observed swimming in the deep holes of that section earlier in the summer. Of all those recovered, 13 (7 males, 6 females) had been marked by clipping the adipose fin. One was recovered 1¼ miles below the Lower Falls, one at the Deer Creek Irrigation Company Dam, five in the Apperson Ranch section, five in the Campbellville section, and one just below Wilson's Cove (Table 4). Eleven

EXPLANATION OF PLATE 11

Above. Loading tank, after removal from stream, being lowered over tank truck preparatory to dumping fish into tank (photo by U. S. Bureau of Reclamation). *Below.* Tank truck for salmon at release site on Deer Creek. Stream water drawn through hose at left was mixed with that in tank until latter approached water of stream in temperature. Salmon then were released by lifting gate at rear of truck and sluiced into marking box in edge of creek.

had spawned completely and two had spawned partly. Complete recovery of all spawned-out salmon in a stream such as Deer Creek is impossible; many slip into deep holes and sink; others are caught under brush and debris in the stream, and some are eaten or carried away by animals. Despite the fact that only 13 of the marked and transferred salmon were recovered during the spawning season, there doubtless were others, both marked and unmarked, that spawned naturally in Deer Creek.

CONCLUSIONS

The recovery of 13 of the marked transferred salmon at points ranging from just above the Deer Creek Irrigation Company Dam to within 1¼ miles of the Lower Falls (a distance of approximately 28 miles) is evidence that a suitable distribution and subsequent natural spawning of the salmon will follow their transfer from the Sacramento River to Deer Creek. Inasmuch as the ultimate purpose of the experimental transfers had been to determine this fact, it was concluded that transfer of larger numbers of salmon could be carried on successfully as a part of the salmon salvage operations relating to Shasta Dam. It was agreed, therefore, that a portion of the early spring run salmon would be removed from the Sacramento River below Shasta Dam and transferred by tank truck to Deer Creek for natural propagation in the latter stream. The number to be transferred each year will be determined by annual investigations of the concentration of both native run and transferred salmon on the available spawning areas in Deer Creek.

FOOD OF HAWKS AND OWLS IN MAINE[1]

Howard L. Mendall
Maine Cooperative Wildlife Research Unit, Orono, Maine

There are numerous published accounts on the food habits of birds of prey, but few relate specifically to the northeastern United States. The present paper deals with information collected in northern Maine from 1920 to 1942. The facts, all derived from analyses of stomach contents, were compiled by the writer from the private journal of the late Walter Clayton of Lincoln, Maine. Clayton was a fur buyer, taxidermist, and naturalist with more than 40 years of experience. He was well known to ornithologists, mammalogists, and entomologists throughout the New England States and no biologist familiar with his work or who had been with him on field trips would hesitate to ac-

[1] Contribution from Maine Cooperative Wildlife Research Unit, Orono, Maine: Maine Department of Inland Fisheries and Game, University of Maine, American Wildlife Institute, and U. S. Fish and Wildlife Service, cooperating.

cept his identifications. No item was identified to species unless Clayton was sure he was correct. His journal bears striking testimony to his scientific integrity, with many notations such as "probably," "apparently," "check further," etc.

Clayton gradually developed an especial interest in the food habits of predatory birds and mammals, and in 1920 began to analyze and record the stomach contents of the animals that he collected or were brought to his shop for mounting. Practically every specimen aside from the snowy owls (which were taken throughout Maine) was collected within 25 miles of Lincoln. During the 23 years, there were several periods of abundance and scarcity in ruffed grouse and snowshoe hares, at least three major invasions of goshawks, and two (1926–27, 1941–42) of snowy owls.

In the autumn of 1941, the present writer discussed with Clayton the possibility of publishing this material, but Clayton died suddenly in May 1942. His widow kindly made the journal available to the writer to extract and tabulate all material on food habits.

Lincoln is in north-central Maine on the Penobscot River, some 60 miles north of Bangor. The collection area is entirely within the Canadian life zone and, except for a narrow strip along the Penobscot River where northern hardwoods predominate, most of the flora is characterized by coniferous forest or mixed woodland in which conifers predominate. White pine once was abundant but much of the present softwood stands consist of red spruce and balsam fir on the uplands and of northern white cedar and tamarack on the lowlands. The Katahdin chain of mountains is close by. The region lies between the two principal agricultural sections of Maine and, except for a few small poultry, dairy, and truck farms, is chiefly forested.

Maine is not heavily populated by hawks and owls. Only two owls are common, the great horned owl and the northern barred owl; the latter is mainly restricted to the northern two-thirds of the State. The other owls are chiefly the long-eared, saw-whet, and Richardson. Of hawks, the broad-winged is most abundant, although there are fair populations of the sparrow, marsh, and sharp-shinned hawks and of the osprey.

Unfortunately, it is impossible to present the material here reported according to the percentage-by-bulk method and the numerical system has necessarily been used. Most food studies of raptors have used the numerical system, however, so that this is not a serious limitation.

GOSHAWK (*Astur atricapillus*)

This hawk is a permanent resident, but uncommon except during invasions from Canada. Clayton examined 37 stomachs representing all months except February and May; most of them were taken in summer and autumn. The digestive tracts of six were empty; the others held the following: poultry, 14 (45%); game birds, 7 (23%)—ruffed grouse in 5, woodcock in 1, black duck in 1; other birds, 3 (10%); snowshoe hares, 2 (6%); red squirrels, 7 (23%); and mice, 2 (6%). Thus these goshawks had preyed largely upon domesticated or wild birds or mammals of value to man; their detrimental qualities were

more pronounced than in any other species represented in Clayton's materials. His analyses resemble those in other studies over the entire range of the goshawk. McAtee (1935) reported on food in 243 stomachs examined by the Biological Survey, of which 116 contained poultry and 40 had game birds. Gross (1928) tabulated the food in 154 stomachs primarily from southern New England during the 1926 invasion. Poultry was present in 82, game birds in 28 (ruffed grouse in 25), and cottontail rabbits in 19. May (1935) reviewed the literature and summarized the results of 881 stomach analyses; over half of them (447) yielded game birds or poultry.

As McAtee aptly wrote: "The goshawk, the largest of the bird hawks, is fierce, audacious, and armed with the most deadly talons of any of the birds of prey. It is able to take what it wants, and as a rule apparently it wants things of value to man." Often it will enter a poultry yard after fowl in the very presence of the farmer.

SHARP-SHINNED HAWK (*Accipiter velox*)

Publications on the food of the sharp-shinned hawk, including those of McAtee and May, show that small song and insectivorous birds make up the bulk of its diet. Game birds seldom suffer because of its small size. Clayton's data are on 20 stomachs (2 empty) taken from April to October; 16 (89%) of these hawks had fed on song birds, and one each had taken frogs, mice, and grasshoppers. Sparrows of various species made up most of the food, being identified in 11 (61%) of the stomachs.

RED-TAILED HAWK (*Buteo borealis borealis*)

Twenty-one stomachs (1 empty) were taken from April to November, the majority in September and October. The variety of food taken included mice, chiefly meadow voles, in 8 (40%); insects in 7 (35%), grasshoppers being a favorite choice; red squirrels in 4 (20%); garter snakes in 2; and one each had taken a frog, shrew, and snowshoe hare. None had eaten game birds, but poultry was found in one, and the bird without food in its stomach was shot while killing a fowl.

Aside from the two instances involving poultry, the food habits of these red-tailed hawks were largely above reproach; the preponderant feeding upon mice and insects was distinctly beneficial. Throughout its entire range, this hawk generally does more good than harm, but occasionally commits depredations on poultry. May's tabulation of more than 1,000 stomachs (of various races of red-tails) showed 112 instances of poultry or game birds being eaten.

RED-SHOULDERED HAWK (*Buteo lineatus lineatus*)

Only 14 stomachs were examined by Clayton, but the results show the usual interesting diversity in feeding habits of this hawk; collections were made from April through September. Insects, a favorite food, were found in 7 (50%), snakes in 3 (21%), and frogs in 3 (21%). One contained a pickerel. Remains of a large bird (apparently a ruffed grouse) were present in one and portions of a snowshoe hare in another. Song birds and shrews (chiefly short-tailed shrews) had each been taken by three (21%). Two digestive tracts con-

tained mice and one held a mass of vegetative debris. No poultry was found. The wide choice of food in Maine agrees with extensive records of Fisher (1893) and of McAtee.

The need for caution in forming hasty judgments on birds of prey is well exemplified in considering the data just presented for both the red-shouldered and red-tailed hawks. Both have traits that may be praised and others that must be criticized; despite their reputation as "hen hawks" they do more good than harm. In Maine, at present, both are so uncommon as to deserve full protection.

BROAD-WINGED HAWK (*Buteo platypterus platypterus*)

The 58 stomachs afford a good seasonal distribution from April through September. Insects, the most important item, were found in 37 (64%)—beetles (and their larvae) in 23, caterpillars in 12. Snakes were in 21 (36%), garter snakes being most frequently identified. Mice—chiefly meadow and red-backed voles—and frogs were next, each being present in 15 (26%); and moles and shrews of several species in 13 (22%). Six (10%) had fed upon snowshoe hares and 5 (9%) upon song birds. Spiders had been eaten by 3 (5%) of the birds. A toad, a red squirrel, and a crustacean were present in one stomach each.

The consumption of snowshoe hares by broad-winged hawks in Maine is regarded as contrary to man's interests. Likewise, the taking of an appreciable number of song birds, moles, and shrews is to the discredit of the hawks since all of these are valuable through their destruction of insects. Most of the hawks had eaten harmful insects—an offset to their detrimental habits; their predations on snakes and frogs represent advantages and disadvantages, possibly in about equal proportions. No instance was noted of poultry or game birds being taken; this gives added strength to the conclusions from previous studies. May's tabulations of 254 stomach analyses showed no records of poultry or game birds. A noticeable point in Clayton's analyses was the presence of snowshoe hares in 6 (10%) of the 58 stomachs. McAtee reported only 2 rabbits in 145 stomachs and remarked that those animals seem rather large prey for this hawk.

The broad-winged now is the commonest hawk in Maine and one of the most persecuted. Its habit of perching on telephone poles and stubs along roadsides and lack of fear of man often leads to its destruction. While not entirely beneficial, it kills less poultry and game than many people claim. As a whole, its food habits are somewhat on the credit side of the ledger.

MARSH HAWK (*Circus hudsonius*)

Thirty-seven stomachs (1 empty) were obtained from April to October. Seven (19%) contained poultry or game birds, remains of a ruffed grouse being present in one and of black ducks in two. Twelve (33%) had fed upon other birds among which various sparrows predominated. Seventeen (47%) contained mice, largely meadow voles, and two held moles or shrews. Two had fed upon insects. The remaining food items were snakes in two stomachs and frogs in three.

Aside from their value in destroying mice, the marsh hawks obtained in

Maine do not show favorable trends in diet as nearly one in five had eaten poultry or game birds. These results do not entirely agree with studies made elsewhere. Fisher rated this hawk as "unquestionably one of the most beneficial" in North America, finding poultry or game birds in only 7 of 124 stomachs; mice were the staple food of the birds examined by him. Errington (1933) found little evidence for destruction of either poultry or game birds during the summer in Wisconsin. McAtee, reporting on 601 stomachs from various parts of the continent, listed 20 as containing poultry and 65 with game birds, but mice made up about half of the food. He concluded that the "economic tendencies of the marsh hawk seem to be about evenly balanced, and the decision as to whether it should be interfered with should be based on local experience—but this should be actual experience or observation, not prejudice." McAtee's comments are corroborated by these studies in Maine, where the local data indicate more destructive tendencies by the marsh hawk than those accumulated by others; the 36 tabulated, however, are too few to condemn the species.

SPARROW HAWK (*Falco sparverius sparverius*)

This species, the only falcon common in Maine, probably is second in abundance to the broad-winged hawk. Only 14 stomachs, obtained from April to October, were examined by Clayton, but the data illustrate the local beneficial qualities of the sparrow hawk. Eight (57%) had fed on insects (chiefly grasshoppers), 6 (43%) on spiders, 2 (14%) on frogs, and 2 (14%) on snakes; one had consumed mice and another had eaten a sparrow. McAtee's report on 703 stomachs showed insects to be the chief source of food with spiders and mice also being freely taken. He rated the sparrow hawk as "almost entirely beneficial."

GREAT HORNED OWL (*Bubo virginianus virginianus*)

Eighty-six stomachs (7 empty) were examined, each month being represented, with a good seasonal distribution. The results were as follows: poultry or game birds, 10 (13%)—ruffed grouse in 4 and wood ducks in 2; song birds, 2 (3%); remains of snowshoe hares, 40 (51%); squirrels, equally red and flying, 8 (10%); mice (meadow and red-backed voles most often), 12 (15%); moles and shrews, 2 (3%); muskrats, 6 (8%); and porcupines, 4 (5%). Insects were of little significance, having been consumed by only 3 birds. A skunk, a woodchuck, and a house rat were represented in one stomach each and there was vegetable debris in 3 cases.

Clayton's journal recorded additional instances of attacks on porcupines by this owl; two of the birds with empty stomachs bore quills showing that they had encountered these well-protected mammals. In three of the six cases recorded, porcupine quills had pierced internal organs and the birds were emaciated, but at least two owls apparently had succeeded in consuming portions of porcupine without experiencing serious consequences.

The great horned owls collected in Maine had taken a lower proportion of poultry and game birds than some of those reported on elsewhere (Fisher, 1893; Errington, Hamerstrom and Ham-

erstrom, 1940), but little can be said in praise of the species in this State. The taking of poultry, game birds, snowshoe hares, and muskrats—all economically important—by more than two-thirds of the owls examined is hardly compensated for by their work as mousers. Nearly all food studies of this owl, on wide or restricted areas and on many or few specimens, indicate that this raptor is generally detrimental to man's interests.

SNOWY OWL (*Nyctea nyctea*)

This owl occurs throughout northern Maine in limited numbers during many winters, but is common only in the "invasions" from Canada. Of the 87 specimens available, 47 were taken during the invasion of 1926–27, and 28 during the 1941–42 influx. The months of November, December, and January produced a majority of them, but during the last period of abundance, eight were collected in October, three of them as early as October 12, 1941. The birds examined by Clayton represented the 5 months from October to February, inclusive.

Of the 87, the digestive tracts in 47 were either empty or contained only unidentifiable debris. Rats and mice were taken most often, being found in 14 (35%), the favorites being meadow mice, white-footed mice, and house rats (the latter in 3); the only other small mammals were shrews, in two instances. Snowshoe hares appeared to be a fairly important source of food, being present in 8 (20%). None of the birds had fed on poultry and apparently only 3 (8%) on game birds—ruffed grouse in two and remains "probably of a black duck" in one. Four (10%) had fed on passerine birds (robins, 3; woodpecker, 1); and digestive tracts of three obtained on the coast contained parts of sea birds—a gull, a murre, and a petrel. Two owls had consumed insects and two others made their last meal on fish. One each had taken a muskrat, a flying squirrel, and a domestic pigeon. Six (15%) contained seeds or other vegetable foods probably derived from the stomachs of victims.

The most extensive published data on the food of the snowy owl is that recently presented by Gross (1944); 205 birds were obtained in the New England States from 1926 to 1942 and 127 stomachs contained sufficient food for tabulation. Of these, 22 contained remains of game birds, divided as follows: black duck, 5; old squaw, 4; American scoter, 3; unidentified duck remains, 2; ruffed grouse, 5; ring-necked pheasant, 3. Domestic poultry was found in 5 stomachs. The Norway rat was the outstanding choice of these owls, having furnished food for 38 of them. Mice of three species were recorded in 22 instances, meadow mice predominating. In the same paper, Gross published data on 32 stomach records collected in Ontario and contributed by L. L. Snyder. Rats, white-footed mice, and meadow mice were outstanding and occurred in 8, 7, and 6 stomachs, respectively. Game birds or fur-bearing animals had been taken by only 3 owls. Gross quotes Sutton on the contents of 60 stomachs obtained in Pennsylvania where cottontail rabbits occurred in 26; chickens in 9; bobwhite quail in 4; ruffed grouse, pigeons, and domestic ducks in 3 each; and pheasant in one; the remaining food consisted chiefly of song birds or small mammals with mice predominat-

ing. Dayton Stoner submitted data to Gross on 24 snowy owls killed or observed in New York State during the 1941–42 invasion—ducks in 6, chickens in 4, and rabbits in 4 made up the principal foods. Gross concluded: "The total number of birds and useful mammals that are eaten is just about equal to the number of destructive mammals, and hence little can be claimed in favor of the snowy owl on the basis of its food habits. However, most of us will agree that this owl does deserve a place on the protected list because of its aesthetic value."

In its Arctic summer home the snowy owl feeds mostly on lemmings and mice (Bent, 1938). Fisher reports on 38 stomachs from the northern United States, Manitoba and Ontario; of 26 with food, "2 contained game birds; 9, other birds; 18, mice; 2, other mammals. . . ."

The snowy owl's capacity for good or harm is governed largely by the relative availability of various birds and mammals. Like the great horned owl, it is powerful enough to use a variety of potential food species. The apparent partiality for house rats and mice may result in considerable good when there is opportunity to exercise this preference. When small rodents are scarce, however, the snowy owl may not be so desirable a visitor. During the influx of 1941–42, several reports were received by the writer of rather extensive depredations by this owl on waterfowl and muskrats in various parts of New England; such instances are also mentioned by Gross (1944). The infrequency of snowy owl invasions and the esthetic value of this spectacular Arctic visitor perhaps merit giving it protection, except where heavy local predation occurs.

AMERICAN HAWK OWL
(*Surnia ulula caparoch*)

The hawk owl is largely diurnal. It is mainly an inhabitant of Canada and only an occasional winter visitor in the United States. In Maine it is less of a rarity than elsewhere in this country.

Results from the 21 hawk owls examined by Clayton constitute a valuable contribution to our knowledge of its food habits. The collections were made from October to January, and all four months are well represented. Clayton's journal records 8 of these taken in October, November, and December, 1925, indicating an exceptionally good "hawk-owl year" in Maine. One stomach was empty; the remainder showed the most restricted diet of any hawk or owl in Maine. All had fed upon mice; except for two which in addition had taken one shrew apiece, no other food items were present. Meadow mice were identified most frequently and also a number of red-backed mice.

References in the literature on the food of the hawk owl are chiefly general statements. Mice, lemmings, ground squirrels, and insects are eaten in summer, and in winter ptarmigan are taken extensively (Fisher, 1893).

The beneficial habits of the hawk owl in Maine are obvious and, together with the rarity of the bird, should ensure it strict protection.

NORTHERN BARRED OWL
(*Strix varia varia*)

Of this owl 136 stomachs were collected in all months except July. Only 7 were empty. The food was heavily of mammals, birds and other animals be-

ing taken much less frequently. Results of the examinations showed mice in 53 (43%)—house rats in 3, but red-backed and meadow mice predominated among the others identifiable to species. Squirrels were present in 24 (20%)—flying, 14; red, 9; grey, 1—a higher proportion of squirrels than in any of the other raptors studied. Snowshoe hares were found in 24 (20%) stomachs and shrews of three species, in 19 (15%); one contained a mink. Of other animal foods, insects predominated, being found in 15 (12%); beetles appeared to be favored, but caterpillars and grasshoppers were often taken, and one stomach held 25 large grasshoppers. Three owls had fed on spiders, 2 on salamanders, 2 on frogs, and 1 on a garter snake. No poultry had been preyed upon, but 5 (4%) owls had consumed ruffed grouse. A warbler and a sparrow were found in one stomach each.

The results in Maine varied from those elsewhere, although most writers agree that this owl is not particularly destructive to poultry and game birds. Fisher examined 109 stomachs, chiefly from the northeastern quarter of the United States; "5 contained poultry or game; 13, other birds; 46, mice; 18, other mammals; 4, frogs; 1, a lizard; 2, fish; 14, insects; 2, spiders; 9, crawfish, and 20 were empty." Bent states that this owl is "on the whole, decidedly a beneficial species, as most of its food consists of injurious rodents and other animals of doubtful value, and it does very little damage to poultry and game."

The data from Maine afford another example among raptors of coexisting beneficial and detrimental qualities that make a fair verdict difficult. The barred owl's apparent fondness for hares probably saves many ruffed grouse from attack, yet the snowshoe hare, generally rated as far less valuable than ruffed grouse, is locally a game species of importance and its high place on the owl's diet is detrimental to the interests of man. Likewise, the consumption of shrews is a discredit. Predation upon squirrels cannot be held against the owl and may even be in its favor, since practically all of those animals taken were flying and red squirrels. The former have little economic value and the latter, being very common in Maine, often are quite destructive to the eggs of song and game birds. The insectivorous habits of the barred owl are, on the whole, commendable, although some beneficial beetles were consumed. An important point in its favor is the absence of poultry in the stomachs examined, and another that only five (4%) had preyed upon New England's favorite game bird, the ruffed grouse.

The present collection, covering 22 years in one locality with all seasons of the year well represented, is a reasonable sample of the barred owl's diet. It would appear to the writer that, contrary to Bent's conclusion, the barred owl is not a beneficial species, at least in Maine. It is less destructive than the great horned owl, but in areas of abundance, its capacity for harm cannot be overlooked. Since it exhibits tendencies in food habits that compensate in part for its harm, persecution of the barred owl should not be encouraged. Reduction in numbers should be undertaken only where the abundance of this owl and the types of its potential prey have indicated real necessity, as on areas where the owl is abundant in grouse

covers and there is a noticeable lack of mice, squirrels, or rabbits, or where the snowshoe hare is of primary importance and where mice and squirrels are scarce. Poultry farmers certainly can find no excuse for "control" measures, and for game interests such matters should be left to trained technicians.

LONG-EARED OWL
(*Asio wilsonianus*)

Sixteen of these owls were taken, throughout the year. The diet consisted almost entirely of small mammals; mice in 14 (88%), with white-footed mice and meadow voles predominating; shrews in 2; a bat in one; and insects in another. No birds or game mammals were taken.

These few data indicate beneficial food habits and agree closely with extensive data for the country as a whole. Of 92 stomachs tabulated by Fisher, a quail was found in one stomach, while 84 contained mice. Bent considers the long-eared owl one of the most beneficial of our birds of prey, as do also McAtee and Beal (1924). The latter point out the relative tameness of this owl, saying: "It is not wary, hence is one of the greatest sufferers where bounties are paid for the destruction of birds of prey."

RICHARDSON OWL
(*Cryptoglaux funerea richardsoni*)

Of this diminutive owl 20 specimens were collected, representing all months except June, July, and August. Only 15 contained sufficient food for tabulation, and gave results of interest in view of the scant published information on this species. Eleven (73%) contained mice, chiefly meadow voles; 3 (20%) held short-tailed shrews; one had the remains of a domestic pigeon; and one contained grasshoppers. Fisher had no specific data; Bent recorded analyses of a few stomachs and concluded that the chief foods are small rodents and insects. This owl appears to be largely beneficial in its food habits.

SAW-WHET OWL
(*Cryptoglaux acadica acadica*)

Our smallest northeastern owl seems to be chiefly beneficial, as are other small owls. There were 27 specimens collected, with good seasonal distribution except for the summer. Six were empty; mice, principally meadow mice, were found in 18 (86%); 4 (19%) had fed on shrews (both short-tailed and water shrews); and one had taken an unidentified song bird.

Fisher examined 22 stomachs; "17 contained mice [one shrew is apparently grouped by Fisher with the mice]; 1, a bird; 1, an insect; and 3 were empty."

MISCELLANEOUS RECORDS

Clayton's journal included several records for additional raptors uncommon in north-central Maine of which few specimens were examined. Eight pigeon hawks (*Falco columbarius*), taken chiefly in the spring and autumn, had shown preferences for song birds: warblers in 2, sparrows in 2, a swallow in 1, and unidentified passerine birds in 3. One other pigeon hawk had fed on insects. Four short-eared owls (*Asio flammeus*), secured during the autumn, had eaten mice exclusively, chiefly meadow voles. Three rough-legged hawks (*Buteo lagopus*) had all fed upon mice. Of two screech owls (*Otus asio*) obtained in winter, one contained a mouse and the remains of a passerine bird, the other an English sparrow. One great gray owl

(*Scotiaptex nebulosa*), shot in January, had eaten 5 meadow mice. An American barn owl (*Tyto alba;* the only authentic record of this species in Maine), procured in December, had fed on two meadow mice. The stomach of a gyrfalcon (*Falco rusticolus*) killed in January contained domestic poultry. A Cooper hawk, obtained in May, contained an unidentified warbler.

CONCLUSIONS

The studies here discussed constitute additional evidence that, as frequently pointed out by leading economic ornithologists, local investigations are needed before a hawk or an owl is condemned simply because it is a bird of prey. Farmers, sportsmen, and even some young wildlife technicians (the last often enthusiastic but lacking ecological experience) should bear in mind that most hawks and owls are beneficial much of the time. Clayton's journal shows that a given predator may sometimes be decidedly useful and again very harmful. A specific example is provided by the snowy owl. Had we only the 30 stomachs taken in November 1926 to evaluate this bird, the evidence would point overwhelmingly to it as a destroyer of game, because remains of ruffed grouse and snowshoe hares predominated in these particular stomachs. Analysis of the entire group of snowy owl stomachs, however, shows a different situation—ruffed grouse are of slight importance in its diet and hares play a distinctly secondary role to mice.

Considering Clayton's entire data, it would appear that only three of the species studied showed strong detrimental tendencies, the goshawk and great horned owl as destroyers of poultry and game, and the sharp-shinned hawk as an important predator on song birds. The northern barred owl perhaps tends to do more harm than good, but certainly is less detrimental than either of the three just mentioned. The marsh hawk is in a doubtful category, with strong capacities for both good and evil, but lacking conclusive evidence in either direction for Maine. The snowy owl occasionally may prove detrimental if rats and mice are scarce, but otherwise its food habits are reasonably satisfactory or at least neutral. All other hawks and owls in Maine are preponderantly beneficial. The writer's conclusions from Clayton's data for the several species are as follows:

Distinctly beneficial
- Sparrow hawk
- American hawk owl
- Long-eared owl
- Richardson owl
- Saw-whet owl

Usually beneficial
- Red-tailed hawk
- Red-shouldered hawk
- Broad-winged hawk

Neutral[1]
- Marsh hawk
- Snowy owl
- Northern barred owl

Primarily detrimental
- Goshawk
- Sharp-shinned hawk
- Great horned owl

Control, even of detrimental species, should be left to persons who know exactly what and why they are controlling. Mistakes in identification by farmers and sportsmen, especially among the medium-sized owls and soaring hawks, are notorious in all states where bounties have been paid. The writer

[1] Those with harmful tendencies generally offset by beneficial traits; or those on which further study in Maine is needed.

knows of instances where the highly beneficial sparrow hawk was being persecuted by game technicians who believed the birds to be sharp-shinned or pigeon hawks. Most hawks and owls are difficult to identify even by trained ornithologists; hence, if poultry raisers and sportsmen in Maine believe that they must control "vermin" their efforts should be confined to the two most detrimental species, the great horned owl and goshawk.

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WINTER FOODS OF THE RUFFED GROUSE IN OHIO[1]

Merrill C. Gilfillan and Hubert Bezdek

Ohio Division of Conservation and Natural Resources, Columbus, Ohio

This report is based on the crop and gizzard contents of 26 ruffed grouse (*Bonasa umbellus*) collected in 1939 by the senior author during November in the beech-maple climax forests of northeastern Ohio, and the digestive tracts of 16 grouse taken in 1942–43 and analyzed by the junior author between November and March from oak-hickory forests of southeastern Ohio. Material was analyzed by the volumetric method of the U. S. Biological Survey.

Frequency of occurrence is an important index of the leading foods and affords a more accurate picture of food preferences than volumetric data. Items that comprise a large volume of the total food may not represent more than one or two individuals; this was particularly true of aspen (*Populus grandi-*

[1] Material collected by junior author is a contribution from Pittman-Robertson Project 4-R, Ohio Division of Conservation and Natural Resources. Material collected in 1939 was analyzed by Robert H. Gensch, U. S. Fish and Wildlife Service and Jack M. Allen, Ohio Wildlife Research Station. A. C. Martin and Lawrence Saylor, U. S. Fish and Wildlife Service aided in identification of plant fragments and insects; A. H. Blickle, Ohio University, checked the identifications by the junior author.

dentata), which made up 97 per cent of the food of one grouse in late November.

Animal food was found in only 10 birds and comprised but a trace of the total food; but these birds were taken when insects were at a minimum.

Plant foods were grouped as seeds, leaves, buds and fruit. Grit was computed as a percentage of the total volume along with the rest of the contents of the digestive tracts.

The 77 identified foods involve 66 species or larger taxonomic groups, five of which comprised over half of the total volume. The noticeable lack of animal food agrees with the work of investigators in other states (Kittams, W. H. Journ. Wildl. Mgt., 7:231–233, 1943).

In the specimens examined, berries comprised 47 per cent and miscellaneous plant material 53 per cent of the food; the latter consisted of all food besides fruit or berries, such as leaves, buds and seeds. The transition from miscellaneous plant food to a predominance of berries during the colder winter months is noteworthy; a large percentage of berry food can be expected in northern latitudes since frost nullifies much of the food value of the vegetative parts of plants. The fruits of greenbrier, sumach, dogwood, grape, and witch-hazel were the most popular foods at this season.

Ruffed grouse have been observed to feed on green fronds of fern (*Polystichum*) in winter but fewer than 2 per cent took this food, despite the fact that this fern is one of the most common green plants at that season in much of eastern Ohio. Rattlesnake fern (*Botrychium*) leaves were eaten by one grouse in November and by another in December, but did not constitute any material quantity of food.

Grasses, mainly seeds, are consumed in limited degree and make but a fraction of the diet; the occurrence of numerous seeds of brome-grass (*Bromus*) in nearly half (41.3%) of the birds from southern Ohio however, is an indication that they are not ingested accidentally.

An excellent example of the importance of availability of food is illustrated by greenbrier (*Smilax*). Scores of droppings, not examined critically, also indicated a preference for this vine.

There are many references in literature to the predilections of the ruffed grouse for buds of the aspen. This tree, although not generally abundant, is common enough to provide sustenance for many of the birds. One individual in northeastern Ohio had eaten 250 buds and several more broken buds could not be counted; this was the only individual showing a preference for aspen. In all, five birds from southern Ohio and seven from northeastern Ohio had eaten buds, principally of aspen.

Buds and fruit of the beech were most frequently eaten by grouse in northeastern Ohio in the beech-maple forest climax.

Pomes of apple were found only 3 times and there was little evidence of preference for the buds of species of the Family Rosaceae. Five-finger (*Potentilla*) is a common herbaceous indicator of acid soils on abandoned open land in southeastern Ohio, but only 12 per cent of the grouse in southern Ohio had eaten parts of this plant.

Clover is usually of dietary importance for grouse at some seasons, but was not often found in this study. Three species of common clover (*Trifolium*), one of bush clover (*Lespedeza*),

and one of medick (*Medicago*) were noted; green leaves were most frequently eaten, although a few seeds were taken. The seeds of vetch (*Vicia*) were eaten by three birds in southern Ohio.

Dogwood is a common food of the ruffed grouse over much of its range, and this shrub constituted part of the diet in nine Ohio grouse. Arbutus (*Epigaea repens*) is a common heath over many rocky hillsides in southern Ohio and its leaves were found in the crops of two birds. Spicebush (*Benzoin*) is probably as common as dogwood in southern Ohio and more consistent in fruiting abundantly year after year, but this spicy fruit is not taken commonly, since only one crop contained a single berry. Witch-hazel was eaten by 17 grouse from Ashtabula County and exceeded all other foods in frequency of occurrence; yet it is not common in southern Ohio.

Some of the other plant foods eaten in limited quantities (but not listed in Table 1) include: wood fern (*Dryopteris*), blue beech (*Carpinus*), hazelnut (*Corylus*), hornbeam (*Ostrya*), chickweed (*Stellaria*), knotweed (*Polygonum*), bramble (*Rubus*), cherry (*Prunus*), wild bean (*Phaseolus*), maple (*Acer*), sour gum (*Nyssa*), partridge berry (*Mitchella*), arrow-wood (*Viburnum*), beggar-tick (*Bidens*), and wild lettuce (*Lactuca*).

In frequency of occurrence, the six most important ruffed grouse foods in northeastern Ohio were: witch-hazel, 65; greenbrier, 50; grape, 46; blue beech, 34; avens, 34; hawthorne, 23. Those in southeastern Ohio were: greenbrier, 81; sumac, 56; dogwood, 44; grape, 31; brome-grass, 31; bittersweet, 25.

TABLE 1.—WINTER FOODS IN 42 DIGESTIVE TRACTS OF RUFFED GROUSE IN OHIO, NOVEMBER THROUGH MARCH 1 (EXPRESSED AS PERCENTAGES OF TOTAL FOOD)

Plant	*Parts Eaten*	
Greenbrier (*Smilax* sp.)	Fruit, few leaves	*15.3*
Aspen (*Populus grandidentata; P. tremuloides*)	Buds	*14.0*
Dogwood (*Cornus florida; C.* sp.)	Fruit	*8.4*
Grape (*Vitis labrusca; V.* sp.)	Fruit	*8.0*
Sumach (*Rhus canadensis; R. typhina; R. glabra*)	Fruit	*7.1*
Beech (*Fagus grandifolia*)	Buds, fruit	*5.5*
Witch-hazel (*Hamamelis virginiana*)	Fruit, floral clusters	*5.3*
Oak (*Quercus alba; Q. palustris; Q.* sp.)	Fruit	*4.5*
Bittersweet (*Celastrus scandens*)	Fruit	*2.8*
Rattlesnake fern (*Botrychium virginianum*)	Fronds	*2.6*
Miterwort (*Mietella* sp.)	Leaves	*2.4*
Apple (*Malus* sp.)	Fruit, buds, leaves	*2.4*
Hawthorne (*Crataegus* sp.)	Fruit, leaves	*2.2*
Avens (*Geum* sp.)	Fruit, leaves	*1.6*
Vetch (*Vicia* sp.)	Seeds	*1.0*
Wintergreen (*Pyrola* sp.)	Leaves	*.8*
Miscellaneous (54 species or larger groups)	Fruit, buds, twigs, leaves	*10.0*
Gravel		*3.2*
Undetermined		*2.5*
Animal food (spiders, insects)		tr.

WARTIME DIET FOR GROWING BOBWHITE QUAIL

Ralph B. Nestler, Leonard Llewellyn, and Merrill Benner
U. S. Fish and Wildlife Service, Patuxent Research Refuge, Bowie, Maryland

In the nutrition studies conducted at the Patuxent Research Refuge on growing bobwhite quail (*Colinus virginianus*) during the past four years, one diet stands out above all others for promoting good growth of chicks, keeping down mortality, and providing a high efficiency of feed utilization. The ingredients are given below. Since fishery products are difficult to obtain during the war, substitutes for them in the preferred diet are considered here.

The formula for the pre-war diet, in parts by weight, was as follows:

Yellow corn, ground	38.5
Millet, ground	10.0
Alfalfa leaf meal, dehydrated	5.0
Sardine fish meal	14.0
Soybean oil meal	26.6
Flavin concentrate (butyl alcohol fermentation residue)	4.0
Limestone, ground	0.6
Salt mixture	1.0
Vitamin A & D feeding oil, fortified	0.3
	100.0

The flavin concentrate was a commercial product of the alcohol industry. A number of such concentrates are on the market, including B-Y Feed, Paco, Produlac, and Curbay. This list is not complete and the inclusion or omission of any name does not imply Departmental endorsement or discrimination.

The salt mixture in the formula was as follows, in parts by weight:

Common salt (NaCl)	50.0
Manganous sulfate, anhydrous	0.85
Ferrous sulfate, anhydrous	0.55
Copper sulfate, anhydrous	0.02
Potassium iodide	0.035
Sodium thiosulfate, anhydrous	0.032
Calcium carbonate	0.035

For practical use the following mixture is suggested, in parts by weight:

Common salt	50.0
Manganous sulfate, anhydrous, technical	2.5
Iodized salt	50.0

In September 1942 Sievert pointed out that the supply of fish meal in the United States then was only about half of normal and that conditions on the Pacific Coast were worse than in the eastern states. As a result of this scarcity, the demand for meat scrap also had become greater than the supply. Subsequently, the conditions have become worse.

Soybean oil meal, when processed at the proper temperature, is the one protein concentrate still readily obtainable that is of high feeding value, and is also one of the most economical of the concentrates. Hayward and associates (1937; see also Ewing, 1941), working with domestic chicks, found that even when soybean oil meal had been heated properly, a mixture of 12 parts of expeller-processed soybean oil meal, 2 parts of meat scrap, and 2 parts of dried milk together with minerals gave superior results to a mixture containing 16 parts of expeller-processed soybean oil meal with minerals in 8-week feeding trials. Bethke and Sweet (1939) compared heat treated, solvent-processed soybean oil meal with expeller-processed meal in the diet of domestic chicks to 8 weeks of age. Both meals

were fed as the sole protein concentrates in diets, and mixed with dried skimmilk and with dried skimmilk, meat scrap, and fish meal. Their results showed that (1) toasted or heat treated, solvent-processed soybean oil meal was equal to expeller-processed meal in feeding value for the chicks; (2) inclusion of 5 per cent of dried skimmilk resulted in significant increases in growth; and (3) further replacement of part of the soybean oil meal by meat scrap and fish meal yielded additional increases in growth. They concluded that optimum results from soybean oil meal are obtained only when fed in combination with some animal protein.

Titus (1943) has cited instances in which "vegetable protein feedstuffs, especially soybean meal, have been used successfully as the chief or sole protein supplement in feeding poultry." He counselled producers to use as much soybean meal as possible and to supply adequate quantities of riboflavin, phosphorus, and calcium; in those instances where the minimum quantity of phosphorus is used, care should be taken to include an adequate quantity of vitamin D in the diet. Satisfactory results should be obtained if these directions are followed and if the diets contain proper amounts of vitamin A, pantothenic acid, and salt.

A recent study (Anon. A, 1942) with pigs showed more efficient gains with solvent-processed soybean oil meal as the sole protein supplement, rather than tankage or expeller-processed soybean oil meal. On the other hand (Anon. B, 1942), experiments with poults gave results definitely in favor of expeller-processed soybean oil meal over solvent-processed soybean oil meal.

Studies on laying pullets by Temperton and Dudley (1941) showed brewers yeast and fodder yeast to be approximately equal to fish meal in a diet largely of corn and wheat products. Finally, the National Research Council (1942) has pointed to butyl and ethyl alcohol fermentation residues, dried brewers yeast, and dried whey as three of several suitable substitutes for dried milk serviceable as sources of riboflavin.

In the light of the above evidence and from other studies at the Patuxent Research Refuge, the authors sought a diet lacking the scarce ingredients yet equal in feeding value to one containing 14 per cent sardine fish meal. The work is far from conclusive, but had to be completed with the data here presented because the national emergency required curtailment of all further studies on the nutrition of game birds.

PROCEDURE

Two experiments were conducted in which ten diets were compared. The second served to complement and check the first, and was started two weeks later with a new batch of quail. In both experiments four diets (Nos. 11, 23, 24 and 28) were used and tested in quadruplicate pens; the remaining seven, in either one or the other experiment, were made in duplicate pens. The composition of the various diets is given in Table 1.

The solvent-processed soybean oil meal had a guaranteed content of 44 per cent protein and 0.5 per cent fat, and the expeller-processed meal (subjected to 260–275°F) of 43 per cent protein and 3.5 per cent fat.

Because of the present scarcity of vitamin A and D feeding oil, cod liver

oil, and other fish oil preparations, D-activated animal sterol (7-dehydrocholesterol activated), in sufficient quantity to supply 540 A.O.A.C. units of vitamin D, was substituted in the original favored formula and in all the other diets used in these experiments. The yellow corn and dehydrated alfalfa leaf meal thus became the primary sources of vitamin A. Normal growth of the birds and their lack of symptoms of A avitaminosis indicated that their minimum requirements for vitamin A were being met. As a precautionary measure against vitamin A deficiency, the level of dehydrated alfalfa leaf meal in all the diets except No. 23 was raised from 5 to 7.5 per cent. According to preliminary tests, this higher level of the meal gave nearly as good results from the standpoints of survival and live weights of the birds and their efficiency of feed utilization, as the 5 per cent level.

The diets also contained ground yellow corn, 10 per cent ground golden millet (except No. 27), special steamed bonemeal (except where other ingredients furnished the required phosphorus), ground limestone, and the salt mixture. All diets were balanced to contain 28 per cent of crude protein, 1.1 per cent of calcium, and 0.7 per cent of phosphorus. The riboflavin content was estimated at about 1900 micrograms per pound for Diet 29; 2300 micrograms per pound for Diets 25, 30 and 31; 1860 micrograms for Diets 11, 26 and 27; and 2100 micrograms for Diets 24 and 28.

TABLE 1.—COMPOSITION OF EXPERIMENTAL DIETS FOR YOUNG BOBWHITE QUAIL.
(all figures are percentages)

Diet numbers	23	11	24	25	26	27	28	29	30	31
Yellow corn, ground	37.8	25.2	23.3	21.3	21.3	21.3	23.2	26.7	26.1	28.6
Millet, ground	10.0	10.0	10.0	10.0	10.0	—	10.0	10.0	10.0	10.0
Wheat, ground	—	—	—	—	—	10.0	—	—	—	—
Alfalfa leaf meal, dehydrated	5.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Soybean oil meal, solvent processed	26.6	50.0	50.0	50.0	—	50.0	40.0	50.0	49.2	44.0
Soybean oil meal, expeller processed	—	—	—	—	50.0	—	—	—	—	—
Peanut oil meal	—	—	—	—	—	—	10.0	—	—	—
Sardine fish meal	14.0	—	—	—	—	—	—	—	—	—
Whey, dried	—	3.0	5.0	7.0	3.0	3.0	5.0	—	—	—
Flavin concentrate (butyl alcohol fermentation residue)	4.0	—	—	—	—	—	—	1.5	3.0	—
Brewers yeast, dried	—	—	—	—	—	—	—	—	—	5.5
Bonemeal, special steamed	—	1.5	1.4	1.4	1.5	1.5	1.5	1.6	1.5	1.4
Limestone, ground	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	1.0
Salt mixture	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sterol mixture (D-activated animal, 1 part; ground yellow corn, 7.33 parts	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1

MANAGEMENT OF BIRDS

The experiments were started rather late for young quail. Experiment No. 1

began during the second week of September with 31 birds per pen and No. 2 two weeks later with 25 per pen. Brooding for the first four weeks was accomplished in batteries in the laboratory and for the next two in outdoor colony brooder pens. After six weeks of brooding, the birds from Experiment No. 1

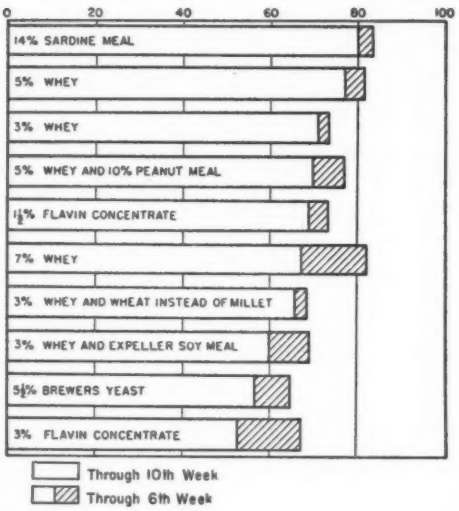


Fig. 1. Percentage survival of bobwhite quail chicks on various growing diets.

were transferred to maintenance pens but those of Experiment No. 2. were kept one week longer in the colony brooder pens because of the cold nights. All birds in both experiments were given maintenance mash in addition to the experimental growing mash from the sixth to tenth weeks. The maintenance mash, by weight, consisted of:

Yellow corn, ground	85.68
Alfalfa leaf meal, dehydrated	5.00
Soybean oil meal	7.00
Special steamed bonemeal	1.20
Salt mixture	1.00
D-activated animal sterol	0.12
	100.00

RESULTS

SURVIVAL

At the end of both the sixth and tenth weeks (Fig. 1), the birds on Diet 23 (14% sardine meal) showed the greatest survival; those on Diet 24 did nearly as well. The survival on Diets 11 and 28 was 70 per cent or better.

A mild outbreak of rhinitis appeared among the birds of Experiment No. 1 but did not become serious. Some picking also occurred in both experiments, but increasing the salt concentration in the diet for several days corrected this condition in most cases. A serious outbreak of self-picking occurred among birds on Diet 30 when they were 7 weeks old; this was checked only by trimming the beaks and swabbing the wounded feet with iodine. There were indications that the feet may have become frostbitten and that the resulting irritation had caused the trouble. Three birds in the same group died from chilling during the brooding period due to failure of a heater.

LIVE WEIGHTS

At the end of the first six weeks (Fig. 2, Table 2), the birds on Diet 23(14% sardine fish meal) had higher weights than those on any other diets. All the differences, except that of average weight on Diets 23 and 30 (3% flavin concentrate), were statistically significant. At the end of the tenth week the birds on Diet 23 still showed the best weights but the only significant differences were between Diet 23 and Diets 24, 25, 26, and 30 (containing 5% whey, 7% whey, 3% whey with expeller-processed soybean oil meal, and 3% flavin concentrate, respectively). Diets

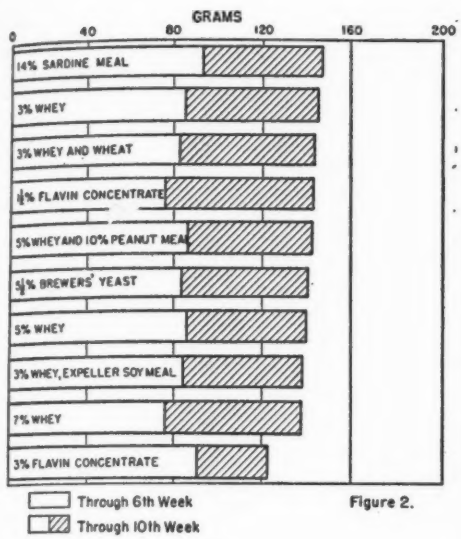
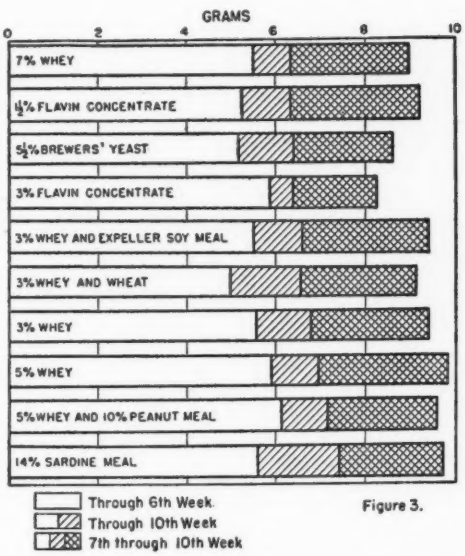


Figure 2.



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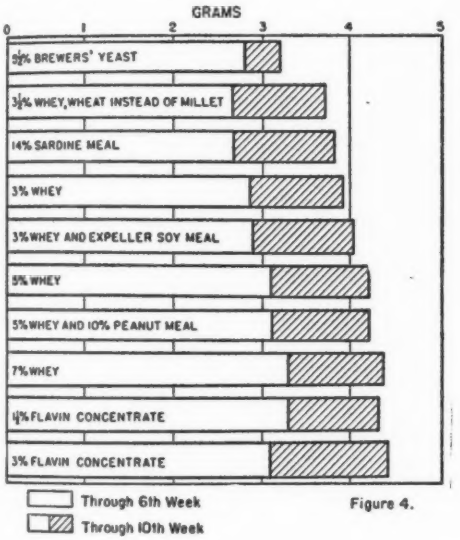

Figure 4.

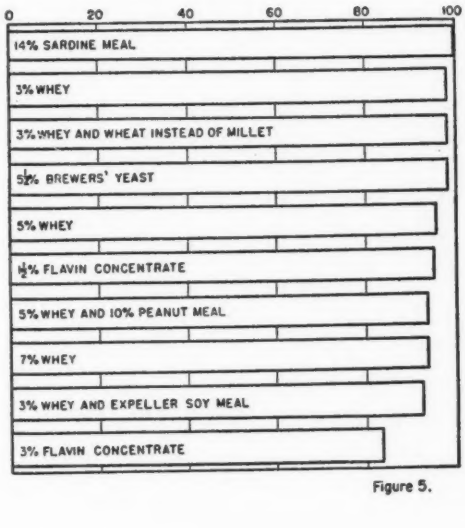

Figure 5.

Bobwhite quail chicks.

Fig. 2. Live weights on various growing diets.
Fig. 3. Quantity of growing mash consumed per bird per day.
Fig. 4. Quantity of feed per gram of gain.
Fig. 5. Ratings of various diets (that with 14% sardine meal considered as 100).

29 and 25 (1½% flavin concentrate, and 7% dried whey, respectively) yielded the poorest weights during the first 6 weeks.

The markedly poor gains, through the seventh to tenth weeks inclusive, by birds on Diet 30 (3% flavin concentrate), undoubtedly resulted from the outbreak of self-picking during the seventh week. The feet were so badly injured that the quail made little attempt to walk to the feeders for several days after cessation of the trouble.

Feed consumption was high on Diet 30 (3% flavin concentrate) during the first six weeks, and then low during the last four weeks in comparison with that on other diets. The weights of birds on this diet had been nearly as much as on Diet 23 at the end of the first six weeks, but were low at the end of ten weeks; hence, there was direct correlation between feed consumption and body weight.

TABLE 2.—EFFECT OF VARIOUS WAR-TIME DIETS ON GROWING BOBWHITE QUAIL.

Diet number and contents[a]	Average live weights in grams at end of 6 weeks	10 weeks	Percentage utilization of diet for body weight during 1st-6th weeks	7th-10th weeks
23. Sardine meal, 14% flavin concentrate, 4%	93.2±1.5	145.3±1.5	*36.9±0.6*	*10.8±0.2*
11. Soy meal, s.p. whey, 3%	86.2±1.6	144.0±1.6	*34.1±0.7*	*12.0±0.2*
24. Soy meal, s.p. whey, 5%	86.8±1.5	139.4±1.5	*32.3±0.6*	*11.5±0.2*
25. Soy meal, s.p. whey, 7%	75.9±2.0	137.9±2.2	*29.7±0.9*	*13.4±0.3*
26. Soy meal, e.p. whey, 3%	85.0±2.5	138.3±2.6	*33.8±1.1*	*11.3±0.4*
27. Soy meal, s.p. whey, 3% wheat (instead of millet)	84.0±2.5	143.0±2.4	*37.0±1.1*	*11.6±0.3*
28. Soy meal, s.p. whey, 5% peanut meal, 10%	86.5±1.6	141.1±1.6	*31.4±0.7*	*11.9±0.2*
29. Soy meal, s.p. flavin concentrate, 1½%	77.1±2.4	142.0±2.4	*30.0±1.0*	*13.0±0.3*
30. Soy meal, s.p. flavin concentrate, 3%	91.1±2.3	122.8±2.5	*32.1±0.9*	*8.6±0.4*
31. Soy meal, s.p. brewers yeast, dried, 5½%	84.0±2.3	140.4±2.4	*35.8±1.1*	*11.6±0.3*

[a] *S.p.*, solvent-processed; *e.p.*, expeller processed.

FEED CONSUMPTION

Throughout the first six weeks the greatest feed consumption (Fig. 3) was on the diet containing 10 per cent of peanut oil meal, whereas for the last four weeks and for the entire 10-week period the greatest consumption was on the diet containing sardine meal.

EFFICIENCY OF FEED UTILIZATION

During the first six weeks, Diets 23, 27 and 31 (fish meal, wheat instead of millet, and brewers yeast) (Fig. 4, Table 2), were utilized most efficiently, whereas for the last four weeks, Diets 25 and 29 (7% dried whey, and 1½% flavin concentrate, respectively) showed the best utilization. For the entire 10-week period, Diets 23, 27 and 31 were still those utilized the most efficiently;

less of those diets was required per gram of gain in weight than of any of the other diets.

RATING OF DIETS

The ten diets were rated on a 4-point basis of survival, live weight, and feed consumption of the birds, and efficiency of feed utilization (Fig. 5). For the first ten weeks, Diet 23 proved to be the best.

Three diets tied closely for second place, one containing 3 per cent whey and 10 per cent millet, the second 3 per cent whey and 10 per cent wheat, and the third 5.5 per cent dried brewers yeast. The birds on the third diet showed lower survival and live weights than those on the other two diets, but consumed less feed and utilized it better.

SUMMARY

Two experiments, using 784 bobwhite quail chicks, were conducted at the Patuxent Research Refuge, Bowie, Maryland, to find a growing diet that would meet wartime restrictions. In 1941 a diet containing 14 per cent sardine fish meal was formulated and gave satisfactory results from the standpoints of survival and growth. Since fish meal now is scarce, search was made for a diet without war-restricted commodities yet equal to the above-mentioned diet in feeding value. Ten diets were compared.

In the present experiments, quail fed this same diet modified by the substitution of 0.12 per cent of D-activated sterol for vitamin A and D feeding oil fortified showed the highest survival and the best live weights at the end of both the sixth and tenth weeks. They also were among the top three groups in requiring the least quantity of feed per unit of gain in weight; however, they consumed the greatest quantity of feed.

Of the other nine diets, that which seemed most promising, considering survival, live weight, and efficiency of feed utilization, was as follows (parts by weight):

Yellow corn, ground	26.08
Millet, ground	10.00
Alfalfa leaf meal, dehydrated	7.50
Soybean oil meal, solvent-processed	50.00
Dried whey	3.00
Special steamed bonemeal	1.50
Limestone, ground	0.80
Salt mixture	1.00
D-activated animal sterol	0.12
	100.00

At the end of ten weeks the results on this diet (Diet 11), as compared with that containing sardine meal (Diet 23), were as follows:

Diet	*No. 11*	*No. 23*
Percentage survival	71	80
Average live weight per bird, grams	144	145
Growing mash consumed, per bird-day, grams	6.8	7.4
Feed consumed per gram of gain in weight (grams)	3.8	3.9

Results were unsatisfactory when expeller-processed soybean oil meal was used in this diet to replace solvent-processed meal. At the end of ten weeks only 60 per cent of the quail survived and the average live weight was only 138 grams.

When the level of dried whey was raised to 5 per cent to provide a margin of safety against abnormal feather growth (resulting partly from riboflavin deficiency), the number of survivals

was nearly as high as on the diet containing 14 per cent sardine meal, but the average live weight per bird was only 139 grams. The difference between this weight and that for the birds on Diet 11 (3% dried whey) was not statistically significant.

The general rating for the diet was as high as that for Diet 11, when ground wheat replaced ground millet in the diet containing 3 per cent dried whey. Survival of birds was 5 per cent-units lower, the average live weight was about the same, and efficiency of feed utilization was higher.

Using D-activated animal sterol as a source of vitamin D and yellow corn and a good grade of alfalfa leaf meal as sources of vitamin A, fish oils were omitted from the diets without causing symptons of avitaminosis. However, because of the instability of vitamin A in storage, it is advisable to include sufficient fish oil, if obtainable, in quail diets to supply at least 2,000 I. U. of vitamin A per pound of feed on a total feed basis.

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WINTER PROTEIN REQUIREMENTS OF BOBWHITE QUAIL

Ralph B. Nestler, Woodrow W. Bailey, Leonard M. Llewellyn and M. J. Rensberger

U. S. Fish and Wildlife Service, Patuxent Research Refuge, Bowie, Maryland

This investigation is the concluding phase of studies on the protein requirements of bobwhite quail (*Colinus virginianus*). Two previous reports have dealt with chicks (Journ. Wildl. Mgt., 6: 185–193, 1942) and breeding birds (unpublished). The present paper considers the optimum protein level of a maintenance diet for semi-mature quail from the twelfth week, and of mature stock to carry them successfully through the winter and prepare them for the reproductive season.

The optimum protein level for quail

chicks, judged from records of survival, rate of growth, and efficiency of feed utilization for the first ten weeks of life, was found to be 28 per cent. During the ninth and tenth weeks, however, the utilization of feed was more efficient on 22 per cent of protein, the lowest level under consideration. The results indicated that after quail have reached about two-thirds of their mature weight, the difference in efficiency between diets with 28 and 22 per cent of protein, respectively, may be small enough to justify use of the latter.

With breeding quail, however, the maximum egg production and weight of females were obtained with 23 per cent crude protein. Differences between various protein levels as to mortality of breeders and the fertility and hatchability of their eggs, were not statistically significant. Never the less, there were indications that for optimum hatchability, the protein content of the diet should not be lower than 15 per cent.

PROCEDURE

From November to March in three consecutive years (1939–41), three experiments were conducted involving 714 bobwhites on the third phase of the series. Only semi-mature stock was used in the first two, but in the last, one-third of the birds on each diet were old breeders. The birds were distributed on the basis of weight and sex, and on age in the third experiment, so that all pens of each experiment were comparable. Experiment I used 15 birds per pen, Experiment II, 32 birds, and Experiment III, 36 birds in each. The birds were housed in maintenance pens 12′×5′×16″ (see U. S. Dept. Interior Conservation Bul. No. 10, pp. 34–38).

In the Experiments I and III the levels of protein were: 9, 11, 13, 15, 17, and 19 per cent, respectively, and in Experiment II: 10, 12, 14, 16, 18, and 20 per cent. These levels were obtained by combinations of the items listed in Table 1. In the first two experiments each diet was fed to a single pen of

TABLE 1.—FEED INGREDIENTS USED IN EXPERIMENTS I TO III ON BOBWHITE QUAIL. (parts by weight)

Experiment	I		II		III	
Mixture	A	B	A	B	A	B
Ground yellow corn	98	58	94.3	59.8	95.2	68.5
Dehydrated alfalfa leaf meal	2	2	2.0	2.0	2.0	2.0
Soybean oil meal	—	—	—	35.0	—	23.0
Ground soybean	—	40	—	—	—	—
Sardine fish meal	—	—	—	—	—	5.0
Special steamed bonemeal	—	—	1.5	0.6	1.8	0.2
Ground limestone	—	—	—	0.5	—	0.3
Mineral mixture I[a]	*ad lib.*	*ad lib.*	—	—	—	—
Mineral mixture II[b]	—	—	2.0	2.0	1.0	1.0

[a] Parts by weight: ground oyster shell, 4; and common salt, 1; kept in separate container.
[b] Parts by weight: common salt, 50; anhydrous manganous sulfate, 0.85; anhydrous ferrous sulfate, 0.55; anhydrous copper sulfate, 0.02; potassium iodide, 0.035; anhydrous sodium thiosulfate, 0.032; calcium carbonate, 0.035.

TABLE 2.—SURVIVAL OF BOBWHITE QUAIL ON VARIOUS LEVELS OF PROTEIN.
(all figures are percentages, except deaths)

Percentage of protein in diet	*9–10*	*11–12*	*13–14*	*15–16*	*17–18*	*19–20*
Experiment I	*100.0*	*100.0*	*100.0*	*100.0*	*93.3*	*100.0*
Experiment II	*90.6*	*90.6*	*87.5*	*84.3*	*84.3*	*100.0*
Experiment III A	*94.4*	*94.3*	*86.1*	*100.0*	*91.6*	*97.2*
B	*97.2*	*97.2*	*83.3*	*97.2*	*91.6*	*97.2*
Combined experiments	*94.1*	*95.8*	*86.6*	*95.0*	*89.9*	*98.3*
Total number of deaths	7	5	15	6	12	2

birds and in the last to duplicate pens.

The limestone and bonemeal were incorporated in such proportions that each feed mixture contained 0.5 per cent each of calcium and phosphorus. Vitamin A and D feeding oil, fortified, was added in Experiment II at 0.2 per cent level, but not in the other two experiments.

Records were obtained on the survival, feed consumption, and live weights of the birds at regular intervals, every 4 weeks for Experiment I, and every 2 weeks for Experiments II and III. Data on reproduction during the subsequent breeding season were collected for birds in Experiment III. Sixteen pairs of birds, wintered on each of the six levels of protein, were so distributed that about the same number of

TABLE 3.—AVERAGE LIVE WEIGHT OF BOBWHITE QUAIL (in grams).

Percentage of protein in diet		*9–10*	*11–12*	*13–14*	*15–16*	*17–18*	*19–20*
Experiment I	Start (Dec. 14)	168	167	168	168	167	167
	Time of Max. Wt. (Jan.)	176	174	174	179	174	174
	Close (Mar. 7)	168	165	170	168	169	167
Experiment II	Start (Nov. 22)	162	163	166	162	163	167
	Time of Max. Wt. (Jan.)	179	178	181	179	179	183
	Close (Feb. 28)	179	172	174	170	170	178
Experiment III A	Start (Nov. 5)	165	166	168	169	170	169
	Time of Max. Wt. (Jan.)	186	187	190	187	188	187
	Close (Mar. 25)	174	174	176	176	176	177
Experiment III B	Start (Nov. 5)	168	166	167	166	165	165
	Time of Max. Wt. (Jan.)	185	186	189	186	189	189
	Close (Mar. 25)	173	176	173	175	174	176
Combined experiments	Start (Nov. 5–Dec. 14)	165	165	167	166	166	167
	Time of Max. Wt. (Jan.)	183	182	185	183	184	183
	Close (Feb. 28–Mar. 25)	174	173	174	173	173	175
Percentage gain at close of combined experiments over initial weight		*5.5*	*4.8*	*4.2*	*4.2*	*4.2*	*4.8*

pairs from each maintenance diet was included on each of six breeding diets.

RESULTS

SURVIVAL

There was only one death (Table 2) in Experiment I, a bird with visceral gout on 17 per cent protein. In Experiment II most of the deaths resulted from coccidiosis. One bird, however, showed symptoms of avitaminosis A even though the diet had been supplemented with 0.2 per cent of fortified vitamin A and D feeding oil. In experiment III "picking" was the primary cause of mortality, especially on the 13 and 17 per cent levels of protein.

LIVE WEIGHTS

In all three experiments the birds averaged about 166 grams each at the start (Table 3), December 14 (I), November 22 (II), and November 5 (III). Gains in weight from 6 to 24 grams were made from the starting dates up to January and losses of 0 to 16 grams occurred from January to March. There were no significant differences between the various levels of dietary protein, high or low, so far as their effect on the weights of the birds was concerned.

FEED CONSUMPTION

In general, there was a tendency for the consumption of feed (Table 4) to increase as the level of crude protein was raised.

PRECOCITY AND PERSISTENCE

During the last week in March, the diet of the birds on Experiment III was changed from that formulated for winter maintenance to another for breeding. The birds maintained on low levels of dietary protein came into production as early as those on the higher levels (Table 5) and persisted in production as long as the latter. In fact, more of the birds on 9, 11, and 13 per cent levels were in production during the first week of May than of those on the 15, 17, and 19 per cent levels. Likewise a higher percentage of the former continued in production through the last week of August.

TABLE 4.—CONSUMPTION OF FEED IN GRAMS PER BIRD PER DAY.

Experiment	Duration	Protein level					
		9–10%	*11–12%*	*13–14%*	*15–16%*	*17–18%*	*19–20%*
I	12 weeks	14.2	13.6	14.4	14.7	13.4	13.4
II	14 weeks	12.5	13.2	13.5	13.4	13.5	14.0
III A	20 weeks	14.6	14.7	15.9	15.4	15.3	15.3
III B	20 weeks	14.7	14.8	15.3	14.9	15.0	15.1
Combined		14.1	14.3	15.0	14.7	14.7	14.8

EGG PRODUCTION AND FERTILITY

The highest production (Table 5) was by birds on 11 and 13 per cent of protein. The average number of eggs per quail for these two groups combined was 75; 19.4 per cent of the birds laid more than 100 eggs each, and one produced 110 eggs. The production on the 9, 15, 17, and 19 per cent levels was 12 to 14 per cent-units lower; the average number per quail was 58, and only one hen laid 100 eggs. None of these differences was statistically significant (by Fisher's "Z" test).

On various levels of protein there was little difference in fertility of the eggs, which in all cases was over 90 per cent. The best hatches occurred on the three lower levels of protein, but none of the differences was statistically significant.

per cent levels of crude dietary protein gave as good results as higher levels and in some respects were better.

On the basis of these studies, it is recommended that the winter maintenance diet for bobwhite quail contain about 11 to 12 per cent of crude protein.

TABLE 5.—REPRODUCTION BY BOBWHITE QUAIL OF EXPERIMENT III DURING THE SUBSEQUENT BREEDING PERIOD.

Percentage of protein	*9*	*11*	*13*	*15*	*17*	*19*
First egg	Apr. 22	Apr. 4	Apr. 29	May 3	Apr. 27	Apr. 22
Last egg	Aug. 31	Sep. 4	Sep. 4	Aug. 31	Sep. 4	Sep. 4
Average days of egg production per hen	95	110	107	96	95	96
Percentage of birds laying during						
Last week of April	*25*	*25*	*25*	*0*	*13*	*6*
First week of May	*50*	*56*	*75*	*31*	*44*	*25*
Last week of August	*62*	*38*	*60*	*38*	*50*	*13*
First week of September	*0*	*6*	*13*	*0*	*6*	*6*
Percentage production for breeding season	*42*	*55*	*55*	*43*	*43*	*41*
Average eggs per hen	57	72	77	61	59	57
Percentage fertility	*94*	*91*	*93*	*92*	*93*	*95*
Percentage hatch of fertile eggs	*82*	*82*	*81*	*80*	*77*	*77*

SUMMARY AND CONCLUSIONS

Three experiments involving 714 bobwhite quail were conducted at the Patuxent Research Refuge, Bowie, Maryland, during the winters of 1939–1941 to determine the protein requirement of quail maintained through the winter.

Considering survival, live weights, feed consumption, and subsequent reproduction by the birds, the 9 to 13 per cent levels of crude dietary protein gave as good results as higher levels and in some respects were better.

On the basis of these studies, it is recommended that the winter maintenance diet for bobwhite quail contain about 11 to 12 per cent of crude protein. The following diet (parts by weight) conforms to these specifications and should be satisfactory:

Ground yellow corn	85.6
Dehydrated alfalfa leaf meal	5.0
Soybean oil meal	7.0
Special steamed bonemeal	1.2
Salt (or Salt Mixture II, see text)	1.0
Vitamin A and D feeding oil, fortified	0.2
	100.0

GERMINATION OF SEEDS AFTER INGESTION BY RING-NECKED PHEASANTS[1]

Wendell G. Swank
Morgantown, West Virginia

Ornithologists and foresters have long recognized the role of birds in seed dispersal. Both field observations and experimental evidence support the claim that a bird may eat fruit at one place and deposit the seeds in a viable condition elsewhere. Zig-zag lines of junipers marking the location of former rail fences, long decayed cherry trees at sites where their presence is difficult to explain, and other similar examples are frequently cited to illustrate the importance of seed dissemination by birds.

Judd,[2] obtained some seeds from crow pellets and these were germinated by A. J. Pieters, of the U. S. Department of Agriculture, demonstrating that regurgitated seeds from fruits eaten by crows are distributed in a viable condition. In his study of the birds on a Maryland farm Judd stated that, "The large consumption of wild fruits results in a wide distribution of seeds, which are voided by birds, and which germinate where they are dropped." On the contrary Roessler[3] found very few seeds were passed in a viable condition through the digestive tract of California linnets. Critical examination of the literature reveals little scientific investigation of this phenomenon.

Many wildlife workers have believed that game birds obtain little of food value from hard-seeded fruits eaten in late winter, and question whether the birds can break the seed coats and digest the kernels. Errington[4] says, "With exhaustion of the available staple foods, the [bob-white] quail tends to fill up on fruits of sumach, wildgrape, rose, coralberry and sundry others of fleshy consistency or composed principally of indigestible seeds."

Barske (Univ. Mich. School of Forestry and Conservation, thesis) proved that seeds of wild rose, sumac, grape. and nightshade, after being broken into a mash form, are digested and provide satisfactory food for ring necked pheasants. Whether the birds themselves could break the seed coats so that the nourishing contents would be available for digestion, was not learned.

The present study sought to determine the kinds and amounts of seeds digested by pheasants and the types that remain viable after passing through their digestive tracts. If a large percentage of hard seeds, such as those mentioned, can be digested, these winter fruits are more valuable than Errington's conclusions would indicate.

Field Work

Clues were sought to indicate the

[1] Acknowledgments are due S. A. Graham and E. C. O'Roke, and the late H. M. Wight under whose direction this work was started: and to my fellow students Robert G. Ohlman, Frank and John Craighead, and Philip Barske.

[2] Judd, Sylvester D., 1902. Birds of a Maryland farm. U. S. Dept. Agric. Biol. Surv. Bul., 17.

[3] Roessler, Elizabeth S., 1936. Viability of weed seeds after ingestion by California linnets. Condor, 38: 62–56.

[4] Errington, P. L., 1936. Nutritive values of winter game foods. N. Amer. Wildl. Conf., Proc., 1: 365.

types of seeds most likely to pass through pheasants and still retain their viability. Droppings were collected in the field and analyzed in the hope of finding entire seeds which had been passed. Collections were made from February until May. Since laboratory analyses revealed few seeds in droppings collected after May 1, when most of the food was green vegetation, collections in the wild were discontinued after that date. Some droppings were collected on key (Ball, 1939). Unbroken seeds were counted and put between moist blotters at room temperature to test their viability.

During February, March and April, 75 sets of droppings were collected, mostly in Superior Township, Washtenaw County, Michigan. This area, typical of southern Michigan farmland, consists of cultivated areas, pasture lands, woodlots, and abandoned fields. The droppings contained 94 entire seeds

TABLE 1.—ANALYSES OF ENTIRE SEEDS IN PHEASANT DROPPINGS COLLECTED IN THE FIELD DURING 1942.

Collections		Species	Number	Percentage germinating	Days for 10 per cent to germinate
Date	Droppings				
February 14	11	Poison sumac	3	*67*	13
15	8	Wild raspberry	5	—	—
20	14	Clover	32	*62*	16
March 2	11	Staghorn sumac	9	*44*	2
8	18	Wild raspberry	1	—	—
		Wild rose	30	—	—
		Clover	5	*80*	12
		Nightshade	5	*75*	12
8	20	Cinquefoil	2	—	—
		Common plantain	1	—	—
		Clover	1	*100*	16
April 1	18	Catnip	2	*100*	24
		Wild rose	1	—	—
21	1	Common plantain		—	—
		Wild raspberry	1	—	—
21	6	Pigweed	8	*100*	10
		Common plantain	3	—	—
		Wild mustard	1	—	—
25	16	Common plantain	23	—	—

the day they were voided, but others remained in the snow for days or months.

Droppings from the field were analyzed immediately in the laboratory. A known number was placed in a soil sieve and flushed with water until completely disintegrated and each particle was distinguishable. Entire seeds and fragments were identified under a 10× binocular microscope by use of a seed of 11 species and 27 of these were viable, a germinating capacity of 26.6 for all entire seeds collected in the field (Table 1).

Some seeds, such as those of nightshade, clover, pigweed, and poison sumach frequently were viable. Two seeds of nightshade had started to germinate before being picked up; this was long before the usual germinating time. Staghorn sumac seeds from

droppings collected on March 2 also had started to germinate. Seeds of some species apparently germinate more quickly when embedded in droppings than in soil.

Seeds of various species of roses and common plantain comprised about two-thirds of all unbroken seeds recovered from the droppings, but none of them germinated; dormancy apparently was not broken either by ingestion by the birds or by cold weather.

To make a limited comparison between the ring-necked pheasant and other gallinaceous birds, a few droppings of the bobwhite quail and the ruffed grouse were collected. The quail droppings were taken from covey roosting spots for one night on four occasions between February 20 and April 21; flocks were dispersing by the latter date. Whole seeds were found only once and were of a verbena, probably blue vervain (*Verbena hastata*). Only three small unbroken seeds were found and two were viable. This leads the writer to believe that the size of the seeds ingested and size of the bird eating them has much to do with the degree of viability of a seed after its passage through the digestive tract. One set of grouse droppings was collected on March 5; it contained two whole seeds of wild rose which failed to germinate.

FIELD PLOTS

To determine the time required and factors contributing to the disintegration of droppings, 10 field plots were established. All were on upland grass-shrub-herbaceous cover, the lower vegetation being principally cinquefoil, blue grass, and clover. Droppings were placed on these plots and began to disintegrate about May 10. There was a decided difference in the rate of disintegration, depending on the thickness of the vegetative cover. On plots with sparse vegetation and thus exposed to the elements, disintegration was rapid, but droppings amid thick vegetation remained unchanged for some time.

The droppings tend to hold moisture for some time after a rain, thus increasing the possibility of seed germination. The droppings are broken up by alternate shrinking and swelling of the individual particles; this results from the changing moisture content and from pounding by raindrops. The rainfall during April 1942 was less than usual, decreasing the chances for disintegration and resulting seed germination. By June 15, the droppings on all plots had disintegrated completely and the plots were covered with a thick mat of vegetation. It was uncertain whether any seeds from the droppings had germinated, but no plants became established from this source. Seeds, such as those of roses, probably would remain dormant for a season after deposition in droppings before germinating.

LABORATORY EXPERIMENTS

Results from the study of droppings collected in the field were suggestive but not conclusive. Clearly certain seeds passed through the digestive tracts of pheasants without losing their viability, whereas others were broken up almost completely and only small fragments remained to indicate their presence. The number of seeds observed in droppings was small. Laboratory experiments with captive birds seemed desirable to obtain more definite information on some of the more important seeds

eaten by pheasants late in the winter.

The species of seeds were selected to meet the following requirements: (1) used as food by pheasants; (2) available in late winter; and (3) with a seed coat strong enough to withstand some of the grinding experienced in the gizzard. The last requirement was considered important at the beginning of the experiments because it then was thought that relatively few seeds ingested by birds would retain their viability.

FEEDING PROCEDURE

Twenty mature female ring-necked pheasants obtained from the Michigan Conservation Department were placed outdoors in wire pens, in groups of five each. The pens were floored with wire mesh, permitting the droppings to fall on to paper placed below. Pine boughs were put into the pens to afford some protection against wind, snow, and rain.

Wild fruits of grape, poison sumac, rose, Virginia creeper, and nightshade were gathered in February and exposed to natural weather conditions on screen wire in the open air until fed to the birds. Millet, flax, alfalfa, and clover seeds were obtained from a seed store. The seeds and fruits usually were offered, one species at a time, together with cracked corn.

Known numbers of seeds and fruits were placed in wire feeding hoppers especially designed to prevent the birds from scattering seeds on the collecting paper without eating them. This was to ensure, as far as possible, that all seeds found on the paper had been ingested by the birds. In the case of fruits, the collecting papers were examined and all whole fruits which had dropped through the screen without being ingested were deducted from the numbers put in the hoppers. After feeding one species of seed and collecting the droppings, the latter were washed thoroughly in a soil sieve. This reduced them to small pieces so that the constituents could be determined when placed in a small water-filled porcelain pan. A 10-power binocular was used for the examinations to ensure that no small seeds, such as those of rose or clover, would be overlooked. The seeds taken from droppings were counted, placed in petri dishes between blotting papers, and placed in a moist chamber at about 70°F. Later they were examined at intervals and any germination was recorded.

CHOICE OF SEED SPECIES

Fruits with hard seed coats were used in the first laboratory experiments because it was thought that only such seeds could withstand abrasive action in the digestive tract of the birds. After learning that some hard coated species remained viable, the experiments were varied to learn the changes, if any, in the percentage of whole seeds passed, and in rapidity and percentage of germination (see poison sumac, Table 3). The experiments then were continued with small seeds to determine whether size has any bearing upon the percentage and viability of seeds passing through the digestive tract. Later a few tests with soft coated seeds, such as flax, were made.

The germination of seeds which had passed through the birds were compared with that of a control group (Table 2). These seeds were taken from the same stock as fed to the pheasants. In the case of fruits, the seeds were

separated from the pulpy portions before being placed in the germinator. The germination procedures were identical for control seeds and those eaten by pheasants.

LABORATORY FINDINGS

Poison sumac (*Rhus vernix*). Of all the seeds collected, poison sumac was considered to be best for a variety of feeding experiments. The fruits are taken readily by pheasants and the sumac seeds without other food (starvation test). On five occasions, the birds were fed poison sumach with cracked corn. There was no uniformity as to the percentage of entire seeds passed by the birds (Table 3), and this was so throughout the laboratory feeding experiments. Seeds of poison sumach passing unbroken through the digestive tract averaged 8.7 (0.04–28.3) per cent.

Seeds egested in an unbroken condition showed high germinating capacity;

TABLE 2.—GERMINATION OF CONTROL SEEDS.

Species	Number tested	Number germinated	Percentage germinated	Days to germinate 10 per cent	Number not germinated within 6 months
Poison sumac	50	31	*62*	38	0
Nightshade	50	10	*20*	6	0
Red clover	50	20	*40*	2	2
Alfalfa	50	40	*80*	2	0
Staghorn sumac	50	4	*8*	—	37
Virginia creeper	50	29	*58*	15	9
Wild grape	50	2	*4*	—	48
Black locust	50	5	*10*	153	32
Barberry	25	3	*6*	—	0
Wild raspberry	50	0	—	—	50
Millet	50	50	*100*	2	0
Flax	50	44	*88*	2	0

seeds are large, reducing the probability of being overlooked when examining droppings. Several of these seeds previously had been taken from pheasant droppings collected in the field, proving that they pass through wild pheasants. Seeds picked out of the feeding hoppers by the birds and then dropped to the trays below without being ingested were easily recognized, because those voided had no fruit covering.

Seeds of this species were offered in five ways: (1) mixed with corn; (2) mixed with poultry laying mash; (3) with corn but without water; (4) sumac alone without other food; few in eight of 10 feeding tests more than half germinated whereas in three tests all uninjured seeds germinated. The average for the whole series of feeding experiments was 70 per cent, and for the control seeds only 20 per cent (Fig. 1).

In every instance the seeds ingested and voided by the birds germinated more quickly than the control seeds. This can be explained by the fact that seeds passed by pheasants had been worn down by abrasive action in the digestive tract. The latter condition was easily recognized under the binocular microscope because ridges on the seeds were absent after being voided by the

TABLE 3.—GERMINATION OF POISON SUMAC SEEDS FED TO RING-NECKED PHEASANTS.

Conditions under which seeds were fed	Seeds put in pens	Seeds taken by birds	Seeds passed in whole condition	Percentage of whole seeds passed	Percentage germinated of those passed	Days to germinate 10 per cent of seeds[a]	Percentage of seeds germinating of those ingested
With mash	400	388	1	*.04*	*100*	19	*0.2*
Sumac alone	3,600	3,527	218	*6.1*	*53*	22	*32.5*
With corn	400	374	45	*12.3*	*73*	26	*8.0*
With mash	400	345	30	*8.7*	*100*	14	*7.5*
With corn	600	583	165	*28.3*	not tested	—	—
With corn	200	189	6	*3.2*	*100*	30	*3.0*
With corn	400	396	36	*9.1*	*97*	20	*8.4*
With corn	400	261	6	*2.3*	*50*	35	*0.7*
Corn, no water	400	396	25	*6.3*	*44*	21	*3.9*
Sumac alone (starvation)	400	329	50	*15.2*	*60*	21	*1.8*

[a] To germinate 10 per cent of seeds in control experiments required 38 days.

pheasants. The digestive juices also may be a factor in this action.

Wild grape (*Vitis* spp.). Grape ranked high as a species to be tested because it met the requirements previously mentioned. The seed coat is hard, the fruits are available in late winter, are readily taken by game birds in the wild, and were available in sufficient quantities for experimental use. The germination of seeds passed by the birds and of control seeds progressed similarly after 20 days in the germinating dishes, and the total germination differed by only

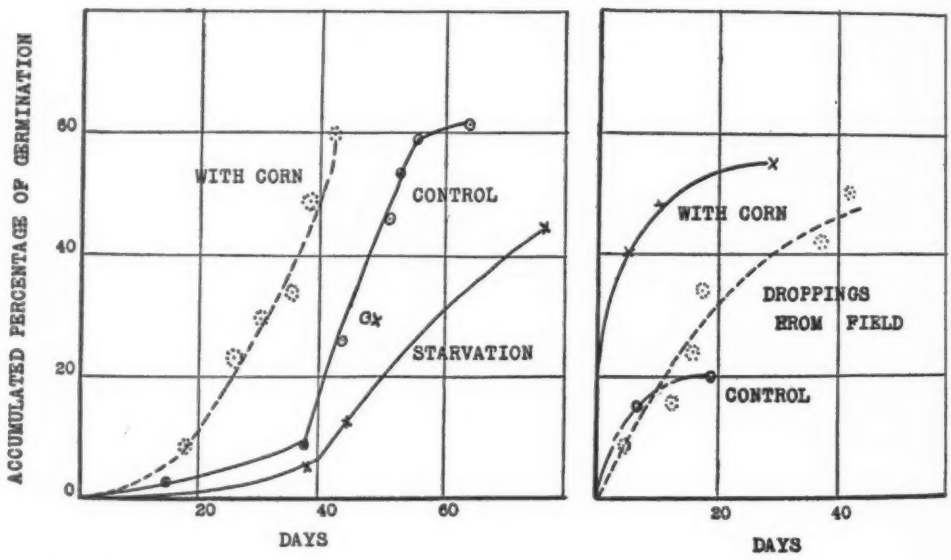

Fig. 1. Percentage germination of seeds of poison sumac (left) and of nightshade (right) from various sources, in relation to ring-necked pheasants.

two per cent. The total germination of grape seeds was low but these seeds normally remain dormant for a full year.

Staghorn sumac (*Rhus hirta*). This is not a preferred food of the pheasant, but was used because it was found in droppings from the field. It is a prevalent species in most eastern states and its fruit is available throughout the whole year. Grouse take fruits of this species readily. There was a wide variation in germination of the seeds.

Black locust (*Robinia pseudoacacia*). This species was tested more to learn the grinding qualities of the pheasant's gizzard rather than for application to

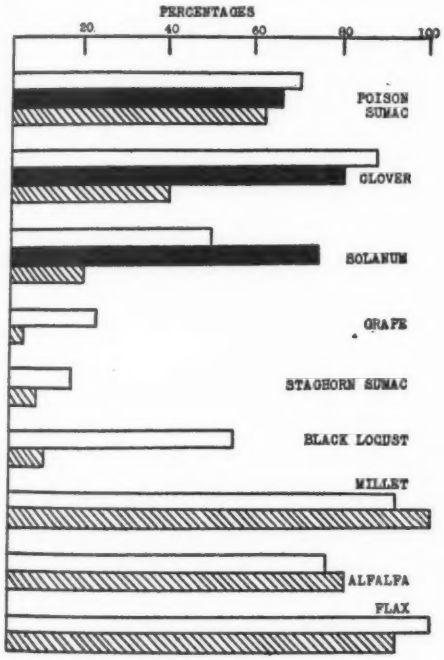

Fig. 2. Percentage germination of seeds experimentally fed (clear areas), of seeds from pheasant droppings obtained in the field (black), and of control seeds (shaded).

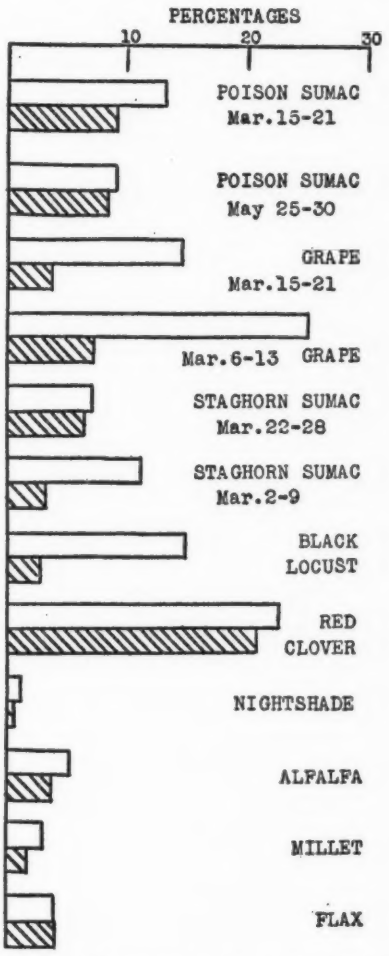

Fig. 3. Seeds eaten by ring-necked pheasants. Percentage passed of those ingested (clear areas); percentage germinating of those ingested (shaded).

wildlife management. The tree is, however, a good forest species and is among the first to invade abandoned lands. The total germination compares favorably with that of other species with hard coated seeds.

Nightshade (*Solanum*). Nightshade is abundant in kettle holes and swamp areas of southern Michigan, is a favor-

ite food of pheasants, and its seeds were found in pheasant droppings in the field. Germination amounted to 53 per cent which leads the writer to believe that the maze of nightshade bushes in many kettle holes frequently originate from bird droppings.

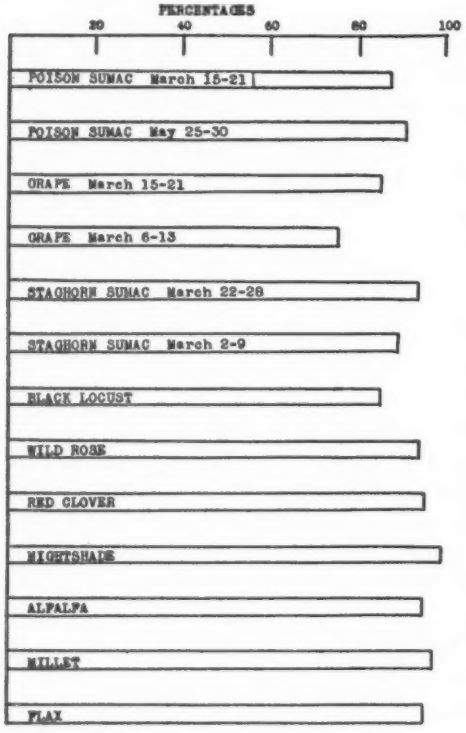

Fig. 4. Percentages of seeds eaten by ring-necked pheasants that were digested.

Alfalfa, Millet, Flax, Red clover. These cultivated species were fed to the birds because they are much used in food plots and are similar to many other seeds eaten by pheasants. If a few of them pass through pheasants without injury, dispersal of valuable food species might be accomplished naturally. Germination was high for the seeds passed, 100 per cent in flax, and 93 per cent in alfalfa. The percentage digested also was high, 97 per cent for millet, and 95 per cent for clover, flax, and alfalfa.

Virginia creeper (*Pseudera quinquefolia*). This plant occurs in quantities along fence rows in southern Michigan, and its fruits remain on the vines into late winter, offering a good emergency ration for wildlife. Few seeds passed through the birds in viable condition; in one feeding no whole seed was found of 748 ingested, but a relatively high percentage (64%) of those passed in an entire condition were viable. Of the seeds in the control experiment, 58 per cent germinated.

Wild rose (*Rosa spp.*). Seeds of the rose are hard and small. Pheasants in the field usually seem to peck the hips apart, eating the pulpy parts of the fruit and leaving the seeds. The caged birds ate the entire fruits. Of the seeds passed in an unbroken condition, none germinated, although they appeared still to be viable. Contrary to the belief of Errington, the pheasants utilized a high percentage of the seeds. In one case 99.3 per cent and in another 89.8 per cent of the seeds were broken and the contents digested. Thus rose hips are valuable not only for the preferred pulpy parts, but the seeds also provide needed late winter nourishment.

Barberry. A high percentage of the seeds were digested, demonstrating that this plant provides valuable winter food for pheasants, besides being an excellent cover plant.

CONCLUSIONS

This study demonstrates conclusively that the ring-necked pheasant distributes seeds of plants such as grape, Virginia creeper, black locust, poison

sumac, and many others with hard coats in a viable condition. Of the seeds of these species ingested by pheasants, approximately 6 per cent are passed in a viable condition. These are dropped in locations frequented by the birds and, if germinating conditions are favorable, valuable food and cover plants are thus disseminated. Once established, the plants produce an annual food crop without replanting. It would seem, therefore, that general dissemination might be accomplished easily by planting a few hard-seeded perennials in spots where pheasants will find and utilize them. Some of these seeds might be added to annual food patch mixtures in the hope of their becoming established adjacent to areas plowed annually for food patches. Better still, plants bearing fruit and seeds that persist through the winter should be established artificially in permanent cover plantings, if present naturally. The ability of the birds to disseminate seeds of the foods eaten will make less cover planting of perennials necessary.

SUMMARY

1. The ability of the ring-necked pheasant to digest certain seeds and the viability of unbroken seeds voided by this bird were studied by collecting droppings in the field and testing the viability of whole seeds contained therein. Feeding tests with captive pheasants were made with a series of representative seeds. Seeds were fed in known numbers, one species at a time, and determination made as to their digestibility and as to the viability of undigested seeds.

2. The percentage of seeds that escape digestion varied between different species; those with hard coats were passed uninjured most frequently. Other things being equal, smaller seeds were passed in greater quantities than large seeds.

3. Seeds that have passed through the digestive tract of the pheasant germinate more quickly than those not exposed to such treatment.

4. Soft coated seeds, such as those of alfalfa, nightshade, millet, and flax, are almost all digested, but some are passed uninjured and viable.

5. Wild grape, which has a very hard seed coat, showed the greatest resistance to breakage in the digestive tract, but more than 75 per cent of the seeds were digested.

6. Contrary to the belief of Errington, a large proportion of rose seeds are broken and digested by pheasants; utilization sometimes is more than 95 per cent of those eaten.

7. It is recommended that seeds for food plot mixtures should include some easily digested and others that are resistant.

8. On management projects, advantage may be taken of the capacity of pheasants to disseminate seeds of food plants in the places they frequent, thus reducing the amount of artificial propagation required to establish adequate food and cover.

PARASITISM BY PROTOCALLIPHORA AND MANAGEMENT OF CAVITY-NESTING BIRDS[1]

Edwin A. Mason
Arcadia Wildlife Sanctuary, Northampton, Massachusetts

Studies of avian nest parasites of the Genus *Protocalliphora* were carried on at the Wharton Bird Banding Station, Groton, Massachusetts, from 1932 to 1941. The presence of this parasite had been noted previously and specimens were sent to Charles W. Johnson, who was then studying the parasites. Tentative conclusions on the data for 1932–1935 (Mason 1935) substantiated the belief of Director William P. Wharton and of Johnson (1930) that excessive mortality of nestling song birds in cavity nests was partly attributable to this blood-sucking parasite. These beliefs were influenced by the known but unrecorded history of a tree swallow colony at the Station, once thriving, then with a protracted period of heavy nestling mortality and decline in the adult population. The nestling mortality drew attention to the presence of *Protocalliphora*, which occurs elsewhere in the United States without markedly upsetting normal avian reproduction (McAtee, 1929).

Conditions at the Wharton Station called for a twofold program of management:

(1) Limit the deleterious effects of the blood-sucking larvae and reduce excessive mortality, by removing one or more infestations from each brood; and

(2) Attempt to favor reproduction of a chalcid secondary parasite (*Mormoniella vitripennis*) and restrain the *Protocalliphora*, by retaining material collected so that adults of the secondary parasite could escape but not those of the primary parasite.

Methods

The practice of collecting the entire contents of nest boxes and substituting hand made nests of hay on one or more occasions while the brood continued in the nest (Mason, 1936) was continued. Later few substitutions were made because the time element involved resulted in destruction of many larvae too small to allow any possible secondary parasitism to run its full cycle. As a result, more of the *Protocalliphora* collected attained growth enough to offer the secondary parasite a chance of completing its cycle. It also was possible to obtain worthwhile data on the degree of secondary parasitism and of successful emergence of the primary parasite.

The entire contents of each nest box was swept into a sheet of newspaper, carefully wrapped and taken indoors. Examination was made as quickly as possible, because some larvae would escape, despite care in wrapping, if the examination was long deferred. The *Protocalliphora* were sorted by size

[1] Joseph C. Bequaert, E. A. Chapin, and Richard Dow determined the insects; William P. Wharton gave assistance and consistent interest throughout the study; and Joseph C. Bequaert gave suggestions and advice and read the manuscript critically.

and counted. All puparia and all larvae large enough to pupate successfully were retained in glass jars with an inch of dry sand. The lid of each jar had many small holes to enable the secondary parasite to escape upon emergence, and for ventilation. When emergence was complete, the contents were again examined. Any intact puparia then were usually broken open; if the first few indicated high secondary parasitism, the material sometimes was retained for a further period.

SPECIES BRED OUT

Large numbers of *Protocalliphora* adults were bred out; many, including all during 1941, were deposited in the Museum of Comparative Zoology. Specimens conformed with descriptions given by Shannon and Dobroscky (1924) for *Protocalliphora s. splendida* Macq., *Protocalliphora s. sialia* S. & D., and *Protocalliphora s. aenea* S. & D. Dr. Bequaert later stated (letter, June 23, 1942): "I have lately come in possession of a box of specimens of *Protocalliphora* gathered by the late Mr. C. W. Johnson. From studying them I am beginning to doubt whether the several races which Shannon and Dobroscky made in the species *splendida* really exist in nature." Hence the parasitic fly here considered is termed *Protocalliphora splendida* Macq.

BASIC DATA

Data for 1932–35 (Mason, *loc. cit.*) and those of 1936–41 are compared in Table 1 for the three principal hosts. Trends in the *Protocalliphora* population and the nesting efficiency of its two chief host species (tree swallow and bluebird) are shown in Figures 1 and 2.

HOST SPECIES

Tree swallow (*Iridoprocne bicolor*). The average number of *Protocalliphora* per brood hatched declined from the high average of 214 in 1935 to 38 in 1941. The average was 146 in the first four years and 90 in the last six. Success evidently was attained by the management methods instituted.

The numbers of nestlings raised of those hatched (the "nesting efficiency") depends on the parasites, on climatic conditions, and on other factors. The most damaging combination is an infestation of parasites, cold weather, and persistent rain, the last not necessarily heavy. Under such weather conditions, there is a reduced food supply and adults must spend more time in gathering food, for both themselves and offspring, with consequent loss of time for brooding. Mortality usually occurs under these circumstances. Nestlings have been robbed of blood by the parasitic larvae and lowered air temperatures call for more bodily heat to offset them; with an abundant food supply the nestling could probably replace both these losses, the degree of replacement being governed by the intensity of the infestation. At these times, however, body fuel is at a minumum. These climatic combinations possibly may occur more frequently in some regions than others.

The tree swallow has maintained a satisfactory nesting efficiency (averaging 82%) over the entire period, with expected ups and downs. The numbers of *Protocalliphora* and the nesting efficiency of the host are not correlated, but there are indications that years favorable to high nesting effi-

TABLE 1.—PROTOCALLIPHORA IN NESTS OF THREE PRINCIPAL BIRD SPECIES AT GROTON, MASSACHUSETTS, 1936–41.

Year	Broods hatched	Broods from which members left nest	Nesting efficiency, percentages[a]	Nests examined (original and substitute)	Uninfested nests, percentages	Protocalliphora: Average number in First nests	Second nests	Third nests	Largest number in one nest	Largest number from one brood	Total larvae or puparia	Average number per brood hatched
TREE SWALLOW (*Iridoprocne bicolor*)												
1936	13	12	*92*	38	*21*	28	46	18	309	373	1,186	91
1937	15	13	*86*	39	*15*	67	98	30	273	383	2,430	162
1938	14	10	*71*	28	*28*	37	24	—	103	169	856	61
1939	15	14	*93*	31	*16*	55	37	23	140	162	1,339	89
1940	11	7	*63*	20	*5*	72	29	54	165	174	1,089	99
1941	11	11	*91*	22	*23*	23	15	—	50	69	424	38
Totals	79	67	—	178	—	—	—	—	—	—	7,324	—
Averages	13	11	*82*	29	*18*	47	41	31	—	—	1,220	90
EASTERN BLUEBIRD (*Sialia s. sialis*)												
1936	7	5	*71*	18	—	65	56	23	194	278	908	129
1937	7	6	*85*	17	*29*	53	25	25	182	218	629	90
1938	10	7	*70*	16	*6*	54	48	—	208	265	816	81
1939	8	7	*87*	15	—	43	31	32	116	138	570	71
1940	2	1	*55*	4	—	93	87	—	128	247	362	181
1941	7	7	*92*	12	—	98	45	6	198	198	878	125
Totals	41	33	—	82	—	—	—	—	—	—	4,163	—
Averages	7	5.5	*78*	13	*6*	68	49	21	—	—	644	113
HOUSE WREN (*Troglodytes a. aedon*)												
1936	4	4	*100*	3[b]	*25*				49		103	34
1937	10	10	*100*	5	*50*				47		101	20
1938	11	11	*98*	5	*54*				43		140	28
1939	7	7	*100*	3	*57*				36		57	19
1940	5	5	*100*	2	*60*				16		22	11
1941	5	5	*95*	2	*60*				8		15	7
Totals	42	42	—	20	—				—		438	—
Averages	7	7	*99*	3	*53*				—		73	19

[a] Based on number raised of those hatched; not reproductive efficiency.
[b] Number of nests infested.

ciency also are favorable for the production of more *Protocalliphora*. The ability of the parasite to be a potential factor in mortality was tempered by removal of its larvae, although this may have been nullified partly by providing new, handmade, unparasitized nests that stimulated oviposition by *Protocalliphora* females. Thus the management consequent to the study may have held to high levels the nesting efficiency of the host, while at the same time increasing the numbers of parasites. This is true for both the tree swallow and bluebird (whose nests were replaced by new ones), but not for other hosts.

Eastern bluebird (*Sialia s. sialis*). Data for this species are less clear cut than those for the tree swallow, being sparse in some years. Thus the high

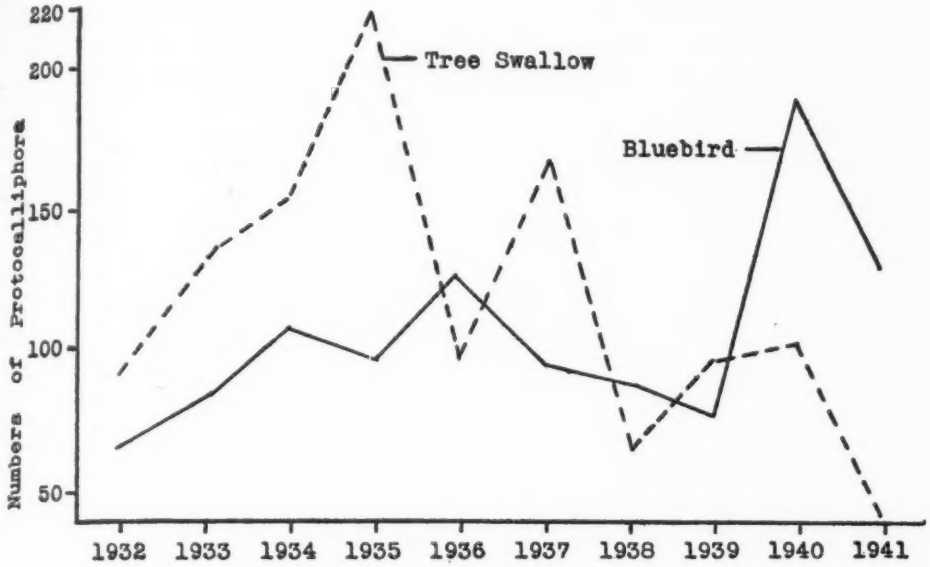

Fig. 1. Average numbers of *Protocalliphora* per brood of birds hatched; based on 112 broods of tree swallow and 71 broods of bluebird.

average of *Protocalliphora* per brood hatched in 1940 rests on only two broods being represented. While data for the first half of the study indicate that the bluebird was less favored as a host than the tree swallow, the second period refutes it. During the first period the bluebird averaged 84 *Protocalliphora* per brood; in the second the average was 113 as compared with 90 for the tree swallow in the second period. The percentage of uninfested nests examined bear on this. For the last 6-year period, 18 per cent of the

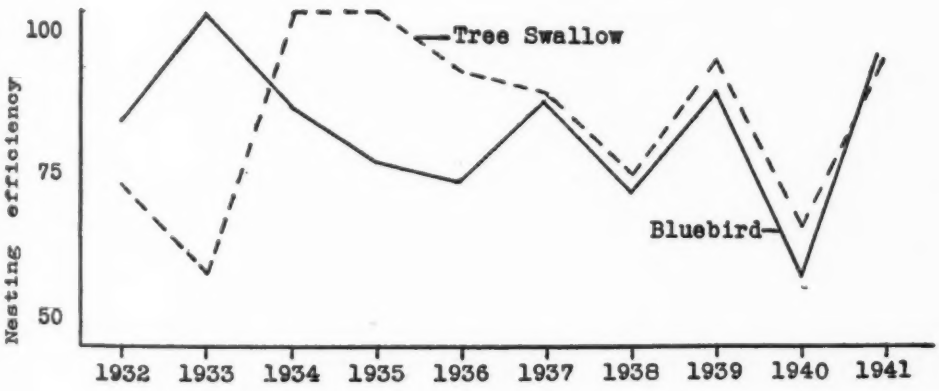

Fig. 2. Nesting efficiency (percentage) of two principal host species.

tree swallow nests were free of parasites, as compared to only 6 per cent of the bluebird nests. The bluebird's nesting efficiency has closely paralleled that of the tree swallow since 1937, indicating a possibility that the controlling factors for the rise and fall of nesting efficiency may be major factors in all avian reproductive efficiency.

House wren (*Troglodites a. aedon*). This host had fewer parasites. The average number of *Protocalliphora* per brood hatched was 4 in the first part of the study and in the last period the average number of *Protocalliphora* per infested nest ranged from 7 to 119; the average for the 6-year period was 19; 53 per cent of the broods were uninfested. The house wren has a particularly high nesting efficiency, averaging 99 per cent for the period. This compares with the 98 per cent noted by Kendeigh (1942, p. 23) for the species in Ohio. (In his table under "Percentages of young hatched that become fledglings".) *Protocalliphora* definitely is not a limiting factor for this species, because its type of nest does not offer a suitable environment for the parasite.

Barn Swallow (*Hirundo erythrogastra*). When mortality was noted while banding 316 nestling broods of this species in 1926–41, the nest was collected and examined if feasible. Four contained *Protocalliphora*, two in 1937 and one each in 1939 and 1941; of these, three were taken in June and one in July. The highest number of larvae was 29, the lowest 4, and the average 15. A nest in July 1937 contained 4 puparia; being broken, it then was believed that they had remained from the previous year. In the nest there were also 2 adults and 1 larvae of *Tenebrio obscurus* Fabr., 2 *Attagenus* larvae (1 identified as *A. piceus* Oliv.), and one each of *Chelifer cancroides* Linn., and *Dermanyssus* sp. (nymph) (determinations by Dr. E. A. Chapin). Because of the possible predatory role of some of these insects, the number of *Protocalliphora* and their condition may have reflected depredations by the insects. Lincoln (1931) referred to parasitism of the barn swallow by *Protocalliphora splendida* Macq. in North Dakota but omitted mention of the number present in the nest. To date the evidence seems to indicate that the barn swallow is parasitized rarely and but lightly.

Robin (*Turdus m. migratorius*). Fourteen nests were examined, as follows: 1938, 6; 1939, 3; 1940, 1; and 1941, 4; all were seen in June, July and August. *Protocalliphora* were found in 8 with an average of 12 per brood examined and 21 per brood infested. There was no indication of host mortality. All nests were collected after the young had left. Some larvae had penetrated the mud lining before pupating.

Starling (*Sturnus v. vulgaris*). Of 4 nests collected in 1938 and 1939, two were infested, one with 11 and the other with 1. The latter contained also 25 carrion fly larvae (probably *Sarcophaga*). One nestling had died and the other had flown. The *Protocalliphora* puparium was parasitized by a chalcid (*Mormoniella vitripennis*), as were 75 per cent of the carrion fly pupae. The usually filthy nests of this alien host do not appear to be particularly attractive to *Protocalliphora*.

Song Sparrow (*Melospiza m. melodia*). Only 2 parasitized nests were found; one on the ground contained 13 larvae and the other about 4 feet up in an

arbor vitae hedge had 30 *Protocalliphora*. Another ground nest contained no parasites. No host mortality was observed.

Other hosts. Nests of the least flycatcher (*Empidonax minimus*), white-breasted nuthatch (*Sitta c. carolinensis*), catbird (*Dumetella carolinensis*), brown thrasher (*Toxostoma rufum*), and chipping sparrow (*Spizella p. passerina*) were examined, but no parasitism was found. Johnson (1930) and Thomas (1936) found *Protocalliphora* in open nests of several small passerines, but seemingly such sites are not so well suited to the flies as those in more subdued light with nests of materials and construction less hazardous to the larvae. Stoner (1936) found slight to heavy infestations of the bank swallow (*Riparia r. riparia*), the heaviest being 108 larvae from two of a brood of four nestlings.

That the nest texture and construction affect the choice of site by *Protocalliphora* or determine whether larvae can grow satisfactorily, seems illustrated by data on the house wren. It is also noteworthy that the average number found in robin nests (which are of open type but constructed so that the larvae could not drop out through the bottom and enter the ground to pupate) is comparatively low and exceeded in some instances by the numbers recorded from other open nests. In this connection, the song sparrow nest from a hedge contained more larvae than one on the ground; the latter was examined thoroughly and 13 larvae were found in the nest material just below the cup but none in the earth immediately surrounding the nest. From the experience in handling many nests from boxes, there is nothing to show that the larvae attempt to descend prior to pupating. The greatest proportion usually are found immediately below the nest cup, often attached to the nest material. Puparia often are covered by a cocoon-like mat of finely broken vegetable matter, and in tree swallow nests this is occasionally of feather material from the nest lining. These observations suggest that the larva is adapted to entering the pupal stage above ground, and that the cocoon-like covering has value as camouflage.

The evidence to date indicates that bird species building open nests are not preferred hosts of *Protocalliphora* and that such infestations as occur are apt to be light, with little danger of ensuing mortality to the hosts. With the bluebird and tree swallow, however, heavy infestations occur, and for the two species as managed during this study, *Protocalliphora* was frequently a potential decimating factor. Nestling mortality can ensue in a tree swallow colony without seriously reducing reproduction, the normal result of the host-parasite relationship under discussion. This topic will be enlarged upon later after the presentation of further evidence.

NOTES ON A NEARBY COLONY

To check experiences at the Wharton Station with those elsewhere, the State Game Farm in Ayer, Massachusetts, about 2 miles away, was visited on July 9, 1936. Edward E. Backus reported that about 12 pairs of tree swallows had raised broods successfully, as evidenced by the numbers seen around the boxes and feeding large young at the entrances. The boxes had been occupied in 1935 and in 1936, the new

nests were on top of old ones. Two nests were collected; from one the entire brood had flown and there was no evidence of parasitism in the old nest.

The current nest contained 40 puparia; *Protocalliphora* flies had emerged from 4, 29 were intact, and 7 broken accidentally contained larvae of the chalcid parasite. From the 29 intact puparia, 1 *Protocalliphora* adult and about 20 *Mormoniella* imagoes had emerged by July 13. There was no further emergence of the primary parasite, but on July 14 over 200 chalcids were in the retaining jar. The final count from this nest showed 85 per cent of the *Protocalliphora* puparia parasitized by *Mormoniella vitripennis*, 13 per cent emerged successfully, and 2 per cent were dead.

Some nestlings had flown successfully from the second nest, and two were dead. One of the latter was less than half grown, the other practically full grown. Mr. Backus reported that one youngster remained three or four days after others of the brood had left. In the nest material were 69 *Protocalliphora* puparia. This box also contained a nest from the previous year, but with no evidence of parasitism. The puparia were retained, but adults emerged successfully from only 4 per cent; secondary parasitism totalled 16 per cent, and the remainder were dead.

In the first nest only one of the 27 parasitized puparia contained chalcid larvae (which evidently would not emerge as adults until the following spring); 5 of the 12 parasitized in the second nest contained such larvae.

Evidently this tree swallow colony was thriving, apparently having retained its numbers and reproduced more or less successfully over many years. The sampling in 1936 showed *Protocalliphora* to be present, but in low numbers; it may have been partially involved in the slight mortality found. The overall picture, however, was of a normal host-parasite relationship.

Other local conditions, discussed later in this paper, probably affected this situation but the most significant factor responsible for this healthy colony is believed to be the management practiced. Customarily the nests were not touched until the following spring, when the contents of the boxes were swept to the ground; thereby the secondary parasite likely would be able to complete its cycle. This practice evidently assisted materially in holding the chalcid population to a high level, and in turn held in check (to a "more normal" level), the avian nest parasite.

EMERGENCE POTENTIAL OF PROTOCALLIPHORA

The number of offspring maturing as adults largely governs the reproductive capacity of a species. It is of interest, therefore, to analyze the information obtained during this study as to the effects of parasitism and predation upon the successful emergence of adults of *Protocalliphora splendida*. Bearing in mind the method used, it would seem likely that both secondary parasitism and predation, especially the latter, would reach higher levels under normal, natural conditions.

The percentages of parasitism, predation, and successful emergence for the 7 primary host species were tabulated. Secondary parasitism increased with advance of the season as overwintering offspring of the chalcid (*Mormoniella*

vitripennis) matured and began to reproduce. The higher percentage rates of secondary parasitism in later nests of the tree swallow and bluebird were as follows:

TREE SWALLOW	*June*	*July*
1936	—	—
1937	*38*	*69*
1938	*47*	*40*
1939	*35*	*67*
1940	*14*	*50*
1941	*29*	*51*
Averages	*27*	*46*

BLUEBIRD	*May, June*	*July, August*
1936	*4*	—
1937	*73*	*5*
1938	—	*31*[a]
1939	*7*	*61*
1940	—	*45*
1941	*2*	*17*
Averages	*14*	*26*

[a] Includes one September record.

The successful emergence of *Protocalliphora* varies from year to year, but should be discounted in host species for which only few data are available. The data for the tree swallow and bluebird are believed to be significant.

The number of *Protocalliphora* per brood hatched showed a general downward trend from 1935 onward (Fig. 1), yet an upward trend in successful emergence was recorded after 1937 (Fig. 3). From year to year there is indication that when the total number of larvae produced is low, the number of flies that emerge successfully to reproduce is high. Here apparently is a natural balance, although the factors involved are obscure.

From the summary (Table 2), it would appear the the secondary parasite finds its host more readily when it is present in nests of some species than when in others. A possible clue may be found in the case of the starling nest referred to previously where there was one *Protocalliphora* larva and 25 larvae of a carrion fly (probably Sarcophagidae). These latter were present as a result of the dead nestling. The rate of parasitism was high (*Protocalliphora*, 100%; carrion larvae, 75%). In 3 tree swallow nests during 1941 in which nestlings had died, parasitism was 51 per cent as compared to 32 per cent for the entire series of tree swallow nests for that year.

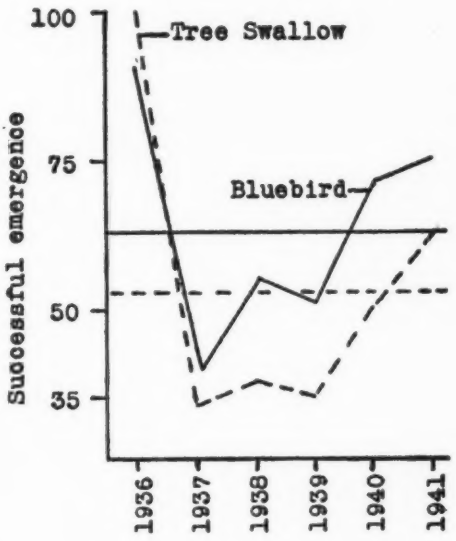

Fig. 3. Successful emergence potential of *Protocalliphora* from nests of two host species; horizontal lines represent average potential for the entire period, 1936–41.

Olfactory perception by the secondary parasite might account for the differing rates of parasitism on *Protocalliphora* with various bird hosts. The cleaner a nest the less odor, with a consequent diminution of attraction to the chalcid and hence less secondary parasitism. Such a hypothesis would correlate the percentage of *Protocalliphora* destroyed by parasites with a scale of nest sanitation, giving the song sparrow

TABLE 2.—FACTORS AFFECTING SUCCESSFUL EMERGENCE OF PROTOCALLIPHORA.

Species and Years	Number of nests	Percentages of Protocalliphora puparia			
		Destroyed by parasites	Destroyed by predators	Died	Successfully emerged
TREE SWALLOW					
1936	1	—	—	—	100
1937	2	*53*	—	*13*	33
1938	7	*45*	—	*18*	37
1939	12	*51*	—	*15*	34
1940	14	*35*	—	*17*	48
1941	16	*32*	1	*6*	61
Total and averages	52	*36*	—	*12*	52
HOUSE WREN					
1936	1	—	—	—	100
1937	2	*36*	—	*3*	61
1938	4	—	—	—	100
1939	2	*55*	—	*8*	37
1940	2	*52*	—	*11*	37
1941	2[a]	*50*	*19*	—	38
Total and averages	13	*34*	*3*	*4*	62
ROBIN					
1938	3	—	—	—	100
1939	1	—	—	—	100
1940	1	*3*	—	*5*	92
1941	3	*12*	—	*21*	67
Total and averages	8	*5*	—	*8*	87
BLUEBIRD					
1936	3	*2*	—	*10*	88
1937	4	*22*	—	*40*	38
1938	7	*18*	—	*28*	54
1939	10	*29*	1	*20*	50
1940	4	*23*	—	*8*	69
1941	11	*10*	—	*16*	74
Total and averages	39	*18*	—	*20*	62
STARLING					
1938	1	*23*	—	*77*	—
1939	1	*100*	—	—	—
SONG SPARROW					
1940	1	—	—	—	100
1941	1	—	—	*10*	90
BARN SWALLOW					
1941	1	—	—	—	100

[a] In both nests the *Protocalliphora* puparia contained dermestid larvae. One *Protocalliphora* puparium contained 8 dead larvae of the chalcid (*Mormoniella vitripennis*), and 1 larvae of a dermestid beetle (*Attagenus piceus* O.).

the highest score for cleanliness, the starling the lowest, and the bluebird scoring higher than the tree swallow. The presence of carrion would of course change the status of an otherwise clean nest. Such a scale of values seems consistent with the known sanitation habits of the species mentioned.

If olfactory perception is a factor in attracting *Mormoniella* to its hosts, a degree of nestling mortality would be essential to releasing the highest po-

tential control of *Protocalliphora* by the secondary parasite. This would account for the results obtained by the management practiced: nestling mortality was held to a minimum, great numbers of *Protocalliphora* adults were restrained from reproducing, the chalcid secondary parasite was unrestrained, and yet the results show the abundance of the nest parasite was only slightly reduced while the population of the secondary parasite failed to rise to high enough levels to be a controlling factor.

OTHER HOSTS OF THE SECONDARY PARASITE

As indicated under the account of the starling, *Mormoniella* is parasitic on carrion larvae. In another instance (1936) a tree swallow nest, in which a large sized nestling had died, contained 5 *Protocalliphora* puparia and 6 carrion fly larvae. From our notes and the light of later experiences, it is likely that the latter were referable to the Sarcophagidae. The *Protocalliphora* were not parasitized, but the carrion larvae were. These records seem to indicate the possibility that *Protocalliphora* may not even be a preferred host of *Mormoniella.*

When the true significance of these isolated instances was realized, it became apparent that here was a factor of major importance in the interrelationships of the species being studied. Girault and Sanders (1909; 1910) have reported on the chalcidoid parasites of *Musca domestica* and its allies in North America, and Roubaud (1917) in Europe. Both refer to *Nasonia brevicornis* Ashmead, synonymous with the earlier name for this member of the Family Pteromalidae of *Mormoniella vitripennis* Walker.

Ten experiments were conducted in 1939 and 1940 in an attempt to substantiate their findings. Exposing carrion in specially built boxes resulted in carrion larvae being raised in large numbers. Despite the unavoidable artificiality of the location and conditions in which the larvae were retained, parasitisms of 2 and 3 per cent resulted. It was impossible to learn whether the chalcid is parasitic in this locality on the ubiquitous and abundant house fly; there is every reason to expect that such is the case. The availability of these alternative hosts in a region would affect the host-parasite relationship of *Protocalliphora* and *Mormoniella* and presumably also would have a direct bearing on the abundance of the avian parasite. Such conditions could account for disparity in the abundance of *Protocalliphora,* both locally and regionally.

Conditions favorable to the production of carrion larvae were found at the nearby tree swallow colony previously mentioned. Birds that died at the Game Farm were buried in a shallow trench, often being in the rearing pens long enough to have attracted carrion flies. The presence of many fly larvae may have been a factor, together with the songbird management practiced, in holding the secondary parasite population to a high level.

DEAD PUPARIA

Of all the *Protocalliphora* examined, 13 per cent were recorded as having "died" (Table 2). This designation refers to those which pupated successfully, but died subsequently from causes other than parasitism or predation. In the majority of instances it seemed obvious that the organisms died very

shortly after pupation, because there was complete lack of form to the remains inside the puparium. The accepted inference is that bacterial or virus diseases were responsible for this condition.

ARTIFICIAL CONTROL OF PROTOCALLIPHORA

Purely artificial controls of *Protocalliphora* were investigated but would not be desirable under most circumstances.

In experiments conducted in Texas, Laake, Parman, Bishopp and Roark (1931) proved that clove oil, clove powder and pine-tar oils would repel the house fly (*Musca domestica*), green bottle fly (*Lucillia* spp.), and black blowfly (*Phormia regina*) from depositing eggs on otherwise desirable material.

GROUND CLOVE

Any repellent used against *Protocalliphora* would have to be inserted into the nest material or box and pine-tar oils seemed out of the question. Ground clove, because of its vegetable origin and dry, powdery texture, seemed suitable; one-half teaspoonful was sifted into the material of each nest a day or two before the young birds were to hatch. When nests were changed during the term of occupancy, another dose was introduced into the new nest material.

Two broods of tree swallows and one of the bluebird were treated during 1940. The tree swallow broods averaged 39 *Protocalliphora* larvae as compared to 99 for the entire series of nests, and the treated bluebird nest contained 247 larvae. Ground clove thus was far from efficient as a repellent of the nest parasite and no attempt was made to use it on a larger scale during the next year. The small amount used created a detectable odor; greater amounts might have been tried but there was the possibility of making nests untenable by the birds.

MOTH BALLS

In 1941 commercial napthalene moth balls were tried, being chosen because it was thought that flake napthalene might dissipate too rapidly. Each of five nests of the tree swallow were treated with two moth balls placed under the nest material. These nests contained an average of 20 *Protocalliphora* as compared to an average of 38 for the entire series for that year. The highest number found was 39 and one nest contained none. The degree of control was low; because of the artificiality of the procedure and difficulty of determining the effects on secondary parasitism, the experiment was not continued.

BLUE COLORED BOXES

Lawrence B. Chapman called our attention to an unsigned popular article, "Do Flies Shun Blue?" in *Technology Review*, May, 1938. This referred to a belief of some architects that flies (perhaps *Musca domestica* especially) shunned the interior of buildings painted blue, especially a medium or "implement" blue. The author referred to hospitals and clinics in France, abattoirs and factories in Denmark, rooms in houses in England, Continental Europe, the West Indies and some South American countries, all painted blue to repel flies. Reference also was made to the experiments in France to determine the preference of flies for colors as indicated by the numbers alighting on squares of

paper of various colors on the walls of a box. "After several days a count of the flies in the box showed that 18 of the insects had chosen to rest on a clear green paper. The next largest number had chosen rose for their resting place, with clear yellow, azure, and clear red following in that order. Only one fly was found on the ultramarine blue. No conclusions were reached as to why flies chose azure blue rather than ultramarine."

When the birds at the Station returned in the spring of 1939, every alternate box in two locations had been painted "wagon blue" in color, and those between were "garden green." Five tree swallow nests from blue boxes averaged 106 *Protocalliphora* as compared to 67 for 5 green boxes and an average of 89 for the entire series of broods of that season. Three bluebird nests averaged 86 as compared to 71 for the series. It would appear that *Protocalliphora* does not shun nests in boxes painted blue.

LIFE HISTORY OF PROTOCALLIPHORA

Many observations on the life histories of the nest parasite and the secondary parasite were recorded during the course of this study; these will be reported in a companion paper. A few items on the former are included here as an aid in understanding the host-parasite relationships discussed.

Coutant (1915) found only the last two instars of *Protocalliphora*, but Dobroscky (1925) found three. All three have been found during the course of this study, and all were external. Many thousands of birds were banded during the study and many ectoparasites were collected from them, but no subcutaneous larvae were found (such as *Protocalliphora hirudo* var. *cuprea*, by Johnson [1931] from the neck of a sparrow near Middleboro, Massachusetts; or *Protocalliphora splendida hesperia*, by Guberlet and Hoston [1940] from a nestling house sparrow, *Passer d. domesticus*, at Seattle, Washington).

Most of the *Protocalliphora* were found in the nest material just below the cup, especially the larvae. There seemed to be a direct correlation between the degree of infestation and the number of larvae attached during the day time. Attached larvae were most commonly on the feet and legs, but also attached to the abdomen and at the bases of the primary feathers. It was exceptional to find them on the crown or nape (as reported by Sargent [1938] for the Cooper hawk), but occasional larvae were observed in the ear cavity. The largest number found was 430, in a tree swallow nest in 1935. The number of larvae present, indicative of the degree of the damage they are capable of inflicting, is related to the sizes and number of hosts present. Jellison and Philip (1935) found as many as 343 and 373 larvae of *Protocalliphora avium* in one nest of the magpie in Montana, but never observed any nestling mortality. Dobroscky (1925) found 343 larvae in the nest of a crow at Ithaca, New York. At the Wharton Station, a weight of 4.55 grams was determined for 108 larvae of all sizes (mostly medium and large) from the nest of a tree swallow (15A, 1937). There was never any indication that infestations killed the hosts prior to reaching a large enough size to complete successfully their own life cycle.

The normal tendency of the larvae is

towards nocturnal feeding, although diurnal feeding is resorted to when heavy infestations are present. Stoner (1936) found the larvae both nocturnal and diurnal on the bank swallow, probably because of the darkness in the nest site of the host.

DISCUSSION

The results from this study are illustrative of the complex interrelations existing in nature. Over-simplified, these may be stated in this case to be as follows:

Nestling birds are dependent upon a food supply of insects, the abundance and availability of which in turn is affected by climatological conditions. Also, particularly in early stages, they are affected adversely by temperatures that reduce bodily heat. If, under such conditions, their basal metabolism is also interfered with by parasites, which reduces their volume of blood, these factors in combination with climatologically-reduced food supplies at times induce nestling mortality, with a consequent lowering of the reproductive rate of the species.

The blood sucking parasite, *Protocalliphora*, is controlled by a secondary parasite, by bacterial or virus diseases, and by insect predators. Success in finding satisfactory hibernating sites probably also affects its numbers. Abundance of the secondary parasite, *Mormoniella*, also is influenced by several conditions. Not being restricted to the bird parasite as a host on which to reproduce, the abundance of the latter alone is not a determinant. The presence of carrion in the area, in turn affecting the abundance of blowflies, enters the equation, as does the presence of manure as a breeding place for the house fly and probably other flies, all potential hosts of *Mormoniella*. Stimulating odors in nests, or the presence of dead birds, must be present to release the highest controlling potential of the secondary parasite.

Predatory insects exercise a lesser role. They probably are attracted to bird nests primarily by odoriferous pabulum and their presence, therefore, is incidental to their customary scavenging habits, as is any depredation which may occur on the nest parasite.

The maximum effects of *Protocalliphora* infestations on avian reproduction would be exerted on the broods of adults inefficient at feeding their young. This is often an attribute of birds nesting for the first time. A pair of capable and assiduous parents can counteract normal infestations by supplying their young enough food to ensure new blood for replacing that withdrawn by the parasitic larvae; the offspring of such parents would have a better chance of surviving to perpetuate the trait. This is an excellent example of natural, selection molding a species.

Local farming practices or the economic level of the persons living in the area may also influence, indirectly, the chain of events.

Biological investigations of unrestrained animal populations usually exert a modifying influence upon the population being studied. Knowledge slowly accrued during the ten years of this study shows that the management earlier advocated for cavity-nesting birds, including that unwittingly practiced prior to beginning the study, was complex and largely inefficient. Measures for farm sanitation, under local pub-

lic health regulations, contributed to the situation. From the data acquired during the study, the practices were modified, however, and it now is possible to propose a new plan of management, particularly for the Northeastern States, to aid in maintaining maximum population levels among desirable insectivorous song birds affected by *Protocalliphora*.

MANAGEMENT

Providing artificial cavities for the nests of certain birds is itself a management practice. Leaving a gourd or bird house until it becomes filled with nesting material to the point where it no longer is desirable to the birds, or disintegrates, is a close approximation to the natural habits of the birds in their use of abandoned woodpecker borings and other cavities. This practice does not interfere with life cycles of the insects normal to cavity nests, hence is a desirable type of management.

With the advent of better bird houses, easily opened for examination and likely to last indefinitely with a little periodic care, a trend developed to increase the attractiveness of such houses to the birds by cleaning out the old nest material. This practice, at the wrong season, would wreak havoc on the checks tending to hold the avian parasite to normal levels, and ultimately would defeat the desired ends of building the bird population to high levels.

Nest boxes should not be disturbed until adults of the controlling secondary parasite have emerged. Since the last of these will not emerge until the following nesting season, a compromise is necessary between the ideal and the practical.

Another method would be to clean only every alternate nest box in any one year, and not before early summer. This might reduce the nesting pairs on a given area unless the density of nest boxes was high, because empty boxes would be preferred by the birds to those containing old nest material.

A second method, more intensive and more practical, would be to clean all boxes once annually at the latest possible date prior to their anticipated occupancy; actual return of the birds would be a reminder of the time for cleaning. Such late cleaning would find brood stock of the secondary parasite not yet emerged and care would be needed to safeguard it. If possible, the contents of each box should be swept into a container, to remain undisturbed and dry in an open shed or elsewhere, so that the chalcid adults could fly freely upon emergence. Otherwise, merely sweeping the contents of a box on to the ground late in spring would be preferable to autumn cleaning.

When nests are visited during their occupancy and nestling mortality is observed, the bodies should be allowed to remain with the other contents until the following spring. Since the odor of carrion apparently is important in releasing the highest potential of the secondary parasite, artificial scenting of nests with carrion odor might be helpful.

SUMMARY

From 1936 to 1941, 162 broods of cavity nesting birds and nests of other species were examined at Groton, Massachusetts, for the nest parasite *Protocalliphora splendida*. Observations also were made on the occurrence of the secondary parasite, *Mormoniella vitri-*

pennis, and information was obtained on the life histories of both insects.

Infestations of *Protocalliphora* were found in 94 per cent of bluebird nests, 82 per cent of tree swallow nests, and 47 per cent of house wren nests. The three species averaged 113, 90, and 19 *Protocalliphora*, respectively, per brood hatched. Their average nesting efficiencies during the period were, respectively, 78, 82, and 99 per cent. Nesting efficiency and the numbers of primary parasistes present probably were held to high levels by the management practiced.

The largest number of *Protocalliphora* in an individual nest was 430. Twelve larvae observed intensively showed the period from inception to pupation to average 9.8 days; from pupation to emergence 11.6 days; and from inception to emergence 21.4 days. Other records indicated the period from inception to emergence of the adult as short as 15 days. Emergence occurs generally between early morning and early afternoon.

In 117 nests of 7 avian host species, 66 per cent of the *Protocalliphora* collected emerged successfully, 13 per cent died, and 21 per cent were parasitized. The successful emergences from nests of the tree swallow and bluebird, were 52 and 62 per cent, respectively.

Protocalliphora is two brooded and the second brood winters over in the adult stage. Infestations from overwintering flies yielded half grown larvae by May 19.

Mormoniella vitripennis is at least two brooded. It winters over in the larval stage and the adults emerge in late spring or early summer after a brief period for metamorphosis. At times, adults emerged from the same puparium in both the year of inception and the following spring. First broods were produced in as short a period as 14 to 15 days, but second broods required up to 9 months to complete the life cycle. The rate of secondary parasitism was about twice as high for the last part of the nesting season as in the first.

Mormoniella has other dipterous hosts, instances of parasitism by sarcophagid flies being found. These may be preferred to *Protocalliphora* as hosts. Olfactory perception may be the means used to locate hosts.

Ground clove and napthalene (moth balls) proved unsatisfactory as repellents of *Protocalliphora* and painting nest boxes blue did not deter the parasite.

The best management to control against *Protocalliphora* is to delay the cleaning of nest cavities until spring or early summer, to safeguard brood stock of the secondary parasite.

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CONTAGIOUS PANOPHTHALMITIS IN DEER[1]

Irene Rosenfeld and O. A. Beath

Department of Research Chemistry, University of Wyoming, Laramie, Wyoming

The frequency and severity of eye infections in wild animals are difficult to estimate since the victims are subject to predation and are destroyed before investigations of the cause of blindness can be made. In consequence, investigational reports of eye injuries in wild life are limited. The injuries comprise three groups: traumatic injuries may result in battles with their own species; mechanical injuries may arise from wounds produced by hunters; and infections are caused by bacterial and virus organisms.

Dixon (1) described a diseased eye condition of unknown origin in the deer of Sequoia and Yosemite national parks as similar to "pink-eye." The infection was widespread in areas of high deer concentration. Inflammation was severe and produced temporary blindness. The deer recovered within two to three weeks if not destroyed by predators. Oberhansley (2) observed eye infection

[1] Published with approval of the Director of the Wyoming Agricultural Experiment Station. Louis E. Coughlin and Don S. Simpson of Medicine Bow National Forest called our attention to this condition and provided animals for autopsy; the U. S. Forest Service furnished photographs of gross specimens.

due to a nematode eye worm (*Thelozia californiensis*). The worms were upon the lower eyelid and others were attached loosely to the conjunctiva. In Wyoming an eye disease of deer in the Big Horn Mountains was reported in 1938 (3). The eyes were described as being covered by blood blisters and the body (a buck deer) was covered with sores. This is the only report of eye infection in wild life in Wyoming.

The authors found blindness among male mule deer (*Odocoileus hemionus*) during the spring of 1943 in the Medicine Bow National Forest, Wyoming. The infection was contagious and indirect evidence suggests that it is transmitted directly from animal to animal. According to the wildlife specialist on that forest, the bucks congregate apart from the does during the spring. Since no infection was observed in females, we consider this as evidence of direct contagion. In each animal observed, one eye and later both become infected; this was readily inferred from the different stages in the infectious processes appearing at autopsy. Many cattle in the same locality were reported to show "pink-eye" infections. The latter occurred in both sexes but were not as severe as those in the deer. We were unable to determine whether there was any connection between the diseased condition of the deer and of the cattle, but the possibility exists that transmission between them occurred.

Ten deer were observed by the game warden showing signs of reduced vision or total blindness; three were brought in for autopsy. They appeared to be in good nutritional state. Loss of weight occurred only in those animals which developed blindness and were unable to obtain food. At autopsy only one (D2) showed some emaciation; the others were in excellent physical condition. Unfortunately we were unable to obtain a live infected animal to carry on bacteriologic investigations and determine the etiological agent.

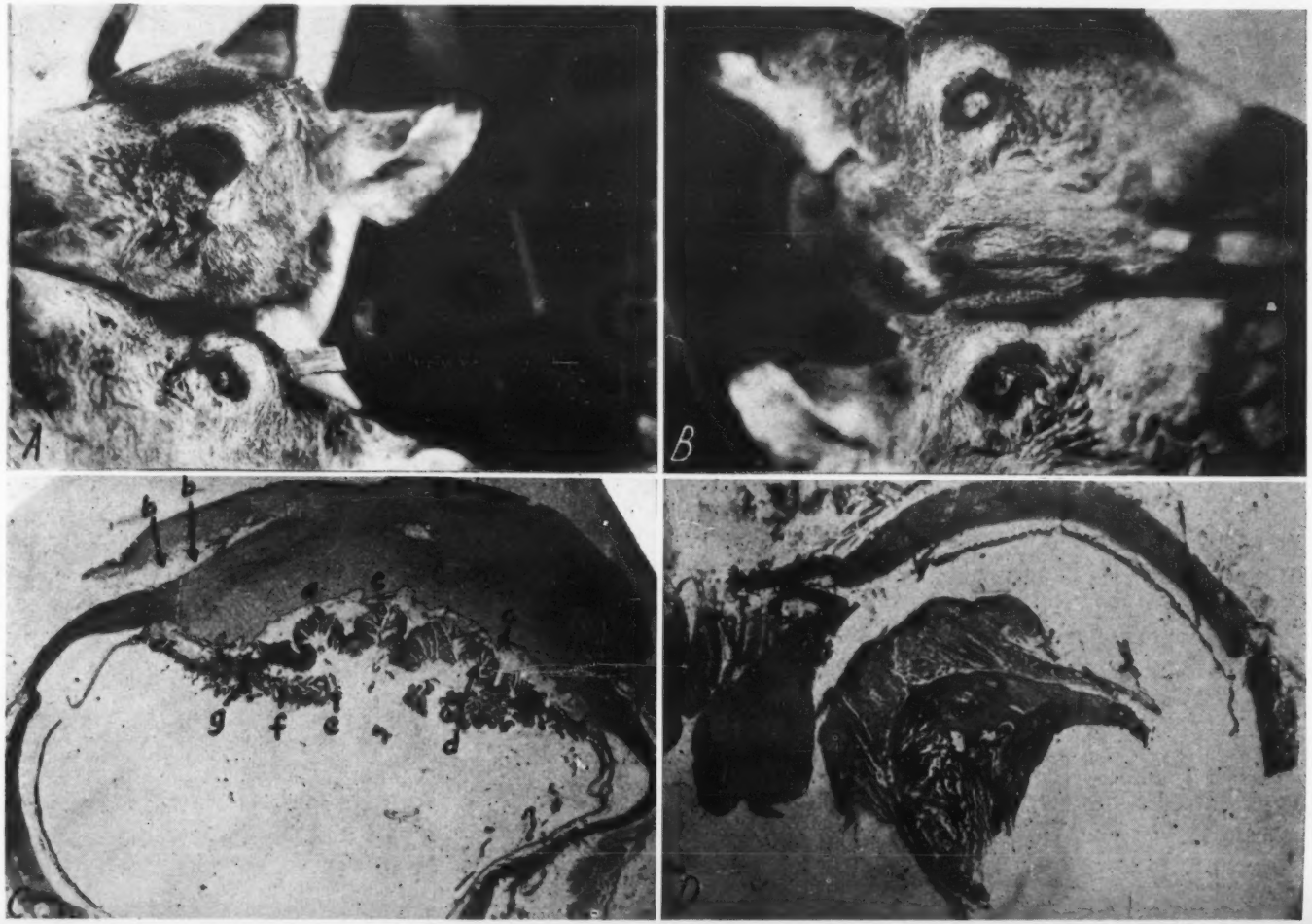
In previous reports, the eye infections usually were self-limited and recovery occurred within a few weeks. The condition in the animals we examined appeared to be progressive, resulting in complete blindness.

GROSS PATHOLOGY

The infected eyes were reddish to opaque in color. One showed grayish opacity covering the cornea and extending to the sclera; another showed acute congestion, hemorrhages with some opacity, and corneal ulceration to which tufts of hair were adhering (Pl. 12, *A*, *B*). The eyes were covered with purulent exudate, which may have been due to their immobility and to inability to wash away foreign particles which continually irritated them. The conjunctiva in acute stages was congested and hyperemic and in more advanced cases appeared adherent to the cornea.

Other accessory parts such as the lids, lachrymal glands, periorbital fat, and eye muscles showed moderate congestion and edema, but there was no evidence of inflammation. The hair surrounding the eyes in some areas was denuded, and in others was covered with purulent exudate forming matted mass around the eyes.

All other organs (heart, lungs, liver, kindeys, stomach, large and small intestines) appeared normal. The brain in some showed slight edema and congestion, otherwise appearing normal.



Panophthalmitis in mule deer. *A*. Tufts of hair adhering to the ulcerated cornea. *B*. Denuded areas and matted hair around the eyes. *C*. Section of eye showing microscopic details: *a*, thickening of cornea; *b*, separation of lamellae, and edematous spaces; *c*, finger-like projections of substantia propria of cornea into anterior chamber of eye; *d*, adherent iris; *e*, elongated finger-like projections of ciliary processes; *f*, homogeneous mass filling ciliary processes; and *g*, edema of ciliary muscles. *D*. Ciliary body filled by hemorrhage and almost obliterated.

Panophthalmitis in mule deer. *A*. Tufts of hair adhering to the ulcerated cornea. *B*. Denuded areas and matted hair around the eyes. *C*. Section of eye showing microscopic details: *a*, thickening of cornea; *b*, separation of lamellae, and edematous spaces; *c*, finger-like projections of substantia propria of cornea into anterior chamber of eye; *d*, adherent iris; *e*, elongated finger-like projections of ciliary processes; *f*, homogeneous mass filling ciliary processes; and *g*, edema of ciliary muscles. *D*. Ciliary body filled by hemorrhage and almost obliterated.

HISTOPATHOLOGY

Cornea. There were localized areas of ulceration destroying the epithelium and Bowman's membrane and invading the cornea. These ulcerations were marginal rather than deep in extent. There were many polymorphonuclear leucocytes present around the necrotic tissue.

The cornea showed extreme thickening (Pl. 12, *C*, *a*) and the corneal epithelium was denuded in the ulcerated areas. The Bowman's membrane was thickened and on the ulcerated surfaces was completely destroyed. The substantia propria showed the most remarkable changes. The lamellae of the fibrous tissue were swollen, structureless, and widely separated, forming wide spaces (*b*), containing some albuminous fluid. Occasional polymorphonuclear leucocytes were present in the spaces of the lamellae, but were completely absent in the deeper layers. The Descemet's membrane was thickened. The endothelium covering the membrane was recognizable in some areas. The endothelium covering the membrane was recognizable in some areas. The substantia propria of the cornea formed finger-like projections which extended into the anterior chamber of the eye (*c*). The iris adhered to the endothelium and to Descemet's membrane, and showed diffuse edema (*d*). Around the smaller vessels there were a few polymorphonuclear leucocytes, many plasma cells, and an accumulation of lymphocytes. Acute congestion, with dilation of the blood vessels and petechial hemorrhages, also were present.

Ciliary Body. Some of the ciliary processes were elongated as extended finger-like processes (*e*). The normal histological structure was completely destroyed by the albuminous edema which filled the reticulum of H. Müller. The pigmented epithelium appeared compressed and on some areas was denuded. Other ciliary processes appeared rounded and filled with a pink-staining homogenous mass that completely obliterated the reticular structure and pigmented epithelium (*f*). The ciliary muscles were widely separated by edema (*g*). A few muscle fibers showed hyaline degeneration. There was an acute hyperemia present.

Lens. No pathologic change.

Choroid. There was acute hyperemia and edema, and limited areas of focal hemorrhages.

Retina. The internal limiting membrane, nerve fiber layers, and inner plexiform layer were distorted and could not be differentiated. They showed vacculation and edema, and were covered with albuminous material. All other layers showed similar changes but not so severe as the changes in the inner layers.

Optic Nerve. An interstitial edema separated the nerve bundles, and involved the nerve fibers in some areas.

Sclera. Some thickening resulted from the edema, but no other pathologic changes were present.

The brain and pituitary showed some edema in the perivascular and perineuronal spaces, and a moderate degree of congestion.

All of the animals autopsied showed similar pathologic changes, except No. D2. In that, the ciliary body was displaced by a large hemorrhage which completely filled the body, obliterating all the structures and destroying some of the ciliary processes (Pl. 12, *D*).

DISCUSSION

The etiologic agent of panophthalmitis in the infected deer was not established, but the evidence points to one infectious in nature. No bacteria could be demonstrated by special stains in the edematous cornea, ciliary body, choroid or retina but there is the possibility of a virus infection. Numerous recent reports in literature have dealt with a "kerato-conjunctivitis." This was first described in Hawaii by Holmes (4); later it was reported in the San Francisco shipyards and subsequently spread eastward from the Pacific coast. Sanders (5) in New York isolated a specific etiological agent which he considers as belonging to a virus group. The histopathology in our cases points toward a virus rather than a bacterial infection. There were some variations in the pathologic changes seen in the eyes examined, but they were essentially the same. In some the infection was in an earlier stage—conjunctivitis or keratoconjunctivitis—and in others the infections progressed to a panophthalmitis, giving a continuity of the pathologic changes which occurred during the different stages of the infection.

SUMMARY

Infection causing panophthalmitis in male mule deer in Wyoming during 1943 was studied grossly and microscopically. The disease processes were not self-limiting but progressive in nature and resulted in blindness.

The causative agent is suspected of being a virus. No direct evidence is available, but the failure to demonstrate any organisms in the deeper layers of the eye suggest a virus infection. Gross and microscopic studies of the viscera revealed no pathologic changes. The brain and pituitary showed moderate edema and congestion, indicating that the infective agent had direct affinity for the infected organ.

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THE WILDLIFE SOCIETY

Report of the Secretary for the Year ending May 1, 1944

Logan J. Bennett, duly elected Secretary for 1943–44, was commissioned Lieutenant (j.g.) in the Naval Medical Reserve on July 15, 1943; after special training in Maryland and Florida he embarked and now is stationed in the South Pacific. The Council appointed P. F. English to fill the remainder of the Secretary's term. Dr. Bennett's secretary, Miss Dorothy K. Sutter, has continued to aid with the routine business for the Society and her helpful services have amounted to about three hours each business day throughout the year.

Despite the trying times, the Society's membership is holding up remarkably well. During the year 54 Active Members and 102 Associate Members were added; also 14 Associate Members became Active Members. Notable among the additions were those obtained by Lee Yeager from the personnel of the Illinois Department of Conservation, 21 Associate Members for 1943 and 36 for 1944. The Secretary brought in 13 Associate Members from the staff of the Pennsylvania Game Commission, including three of the Commissioners.

The membership in good standing on April 21, 1944, totalled 811 (paid up for 1944: active, 306; associate, 360; 1943 members not paid for 1944: active, 48; associate, 97). Subscriptions for 1944 numbered 184 (library, 146; individual, 38).

A compilation by the Secretary of the membership by regions from 1937 to 1944 showed gross losses of 144 Active Members and 407 Associate Members during the seven years. Lists of delinquents, by years and regions, have been prepared and are available to Regional Representatives upon request for use in seeking membership of former affiliates of the Society.

The Secretary compiled the annual list of members in good standing for 1943; this was mimeographed in the Editor's office and mailed during June. The list was prepared in time for use by the President and Chairman of the Membership Committee in conducting a drive for new members.

It is heartening that many of those in the armed forces are paying their dues regularly. It is difficult to keep their addresses up to date, and a wise majority of the service men have their numbers of The Journal mailed to permanent addresses.

Officers and regional representatives for 1944–45 elected by mail ballot are as follows: President, O. J. Murie; Vice-President, L. E. Yeager; Secretary, P. F. English; Treasurer, D. E. Wade; Regional Representatives: Region 1, John Pearce; Region 2, E. V. Komarek; Region 3, W. W. Chase; Region 4, E. R. Kalmbach; Region 5, A. E. Borell; Region 6, P. R. Needham.

Five members were lost by death during 1942 and 1943: H. M. Wight, Michigan; Howard A. Kelley, Maryland; Robert T. Thayer, Connecticut; S. M. Pell, Michigan; and James Moffitt, California.

P. F. English, *Secretary*

REPORT OF THE TREASURER FOR THE CALENDAR YEAR 1943

The office of the Treasurer was moved from Urbana, Illinois, to Hanover, New Hampshire by July 1943. Excellent assistance was given during the year by the former Treasurer, L. E. Yeager, and by the Secretary, L. J. Bennett, and his successor, P. F. English.

In general, the methods of bookkeeping and other procedures used by previous treasurers have been followed. Some additional measures to lessen the work of the Secretary and Treasurer are being worked out by these officers. Collections for 1943 and for 1944 have come in satisfactorily. The Treasurer failed to bill subscribers for 1944, yet 146 of them had paid up by April 17; of the 76 still outstanding, not all will pay. These 222 possible subscribers for 1944 compare with the highest previous number of 171 in 1941.

The Treasurer submitted dues statements to the membership on November 1, 1943 rather than about January 1. A total of $1,681.00 was collected in November and December from these early statements. This compares with similar collections of $1,872.00 in 1941 and $1,809.00 in 1942. The lowest balance (which always occurs after the payment of the October issue of The Journal) in 1943 was $1,639.00 as compared with $1,300.00 in 1942 and $302.00 in 1941. At no time during the year was the Society threatened by a deficiency of funds. The balance at the end of the year was $2,972.17.

The total of funds received during 1943 was $4,278.00; this added to the December 1942 balance of $2,209.00 totalled $6,487.00 which was the amount available for the calendar year.

In 1943 The Journal of Wildlife Management costs were $3,049.00, an increase of $355.00 (13%) over 1942. The increase in pagination was from 390 in 1942 to 432 in 1943 (10%) and the number of articles rose from 45 to 70. Wildlife News (Vol. 2, Nos. 3 and 4) cost $129.00. This news quarterly was suspended for the duration by action of the Society at its 1943 meeting at Denver. The membership list (incidentally, already very much out of date) was prepared in mimeographed form by the Editor with a 60 per cent saving as compared with publication in The Journal.

General administrative costs were $224.00 in 1943 as compared to $465.00 in 1942. Clerical help costs reached a new-time low in 1943 of $14.50 as compared to $48.75 in 1942. The Treasurer's fidelity bond of $3,000.00 was maintained during 1943.

Financial assistance was given during the year to the publishers of Biological Abstracts and also to the Union of Biological Societies which is preparing a special bulletin for distribution in South American countries.

Total disbursements for 1943 were $3,515.65 as compared to $3,476.70 in 1942. As of April 18, 1944, the bank balance was $4,303.07. This substantial sum, barring disastrous events, should ensure an adequate balance for beginning work in 1945.

The Society thus far has weathered the crisis imposed by wartime conditions and is now in the finest financial circumstances since the founding year. Credit for this situation should go to those persons and to the Membership

Committee who have been most active in obtaining new members. Credit also should go to members now in the armed forces, many of whom have kept up their memberships with unusually fine spirit. Those in the armed forces who suspended their memberships did so reluctantly and with every intent of rejoining after "the duration." Efforts should be made to let all these men know that the Society is weathering the storm and thinking of them.

DOUGLAS E. WADE, *Treasurer*

FINANCIAL STATEMENT

For the Calendar Year 1943

Balance (December 31, 1942)	$2,209.08	
Receipts (from members, subscriptions and back numbers)		
Collected by Yeager, Jan. 1 to May 3	1,860.74	
Collected by Wade, May 1 to Dec. 31	2,418.00	
Total Balance and Receipts[1]		$6,487.82
Disbursements:		
General Administration		
Stationery and printing	$ 81.50	
Postage, telegrams and express	52.17	
Clerical assistance	14.50	
Bank charges and special-collection checks	20.77[2]	
Treasurer's expenses and fidelity bond	35.88	
Editor's expenses	20.00	
Publications		
Journal of Wildlife Management (4 issues)	3,049.36	
Reprints (Constitution)	4.14	
Wildlife News (Vol. 2, Nos. 3 and 4)	129.03	
Membership list (mimeographed)	48.30	
Other appropriations:		
Biological Abstracts	50.00	
Union of Biological Societies	10.00	
Total Disbursements		$3,515.65
Balance (December 31, 1943)		$2,972.17

Signed: Douglas E. Wade, Treasurer
The Wildlife Society

[1] Total receipts include some dues for 1941 and 1942, and $1,681.00 in dues and subscriptions for 1944 and 1945 received during November-December, 1943.

[2] Includes three checks ($14.00) received again later and redeposited.

MINUTES OF THE ANNUAL MEETING

The eighth annual meeting of The Wildlife Society was held in the LaSalle Hotel, Chicago, Illinois, on April 24, 1944, at 8:00 p.m., President Taylor presiding; all officers (except the Vice-President) and about 100 members were in attendance. Reading of minutes of the 1943 meeting was dispensed with since they were printed in the July 1943 issue of The Journal. The President appointed a Committee on Resolutions for the current meeting with

T. H. Langlois as chairman. Reports of the President, Secretary and Treasurer were received and filed, and also that of the Auditing Committee which found the accounts of the Society in excellent condition. Reports in person or by letter were made by all regional representatives; these are filed with the Secretary. Business transacted by the Council in its annual meeting on April 23 was reported and discussed; the recommendations were approved except for action by the Society as reported in these minutes. (A report of the Council's business is printed on p. 255.)

Discussion of the proposed amendment to Art. IV, Sec. 2 of the constitution led to the following motion being made, seconded, and passed (by a divided vote): "It is the sense of this meeting that the present system whereby the President and Vice-President cannot succeed themselves be continued and that the proposed amendment permitting this re-election be defeated."

The Committee on Awards recommended the issuance of an award scroll to H. S. Mosby and C. O. Handley for their volume on "The wild turkey in Virginia" and another to Richard Gerstell for his paper on "The place of winter feeding in practical wildlife management." Report accepted and approved. The Committee proposed that more definite rules be established regarding the issuance of awards. A motion was made, seconded, and passed directing the President to appoint a committee to study the subject and report at the next annual meeting.

The Finance Committee submitted the following budget for 1944:

Journal of Wildlife Management	$3,000
Reprints for the Society	50
Editorial expense	50
Stationery and printing	200
Postage and express	200
Clerical assistance for Secretary and Treasurer	100
Treasurer's expense	25
Contingent fund	200
Total	$3,825

A motion was made, seconded, and passed to refer the problem of best use of unallocated funds to the incoming Council for action.

A short report for the Employment Committee was made by W. R. Van Dersal.

A report of work by the Membership Committee was made by Phil Goodrum and filed with the Secretary.

Work of the Wartime Committee was reported by E. L. Palmer as to both current and possible post-war activities in fields related to that of the Society. The report is filed with the Secretary.

Editor T. I. Storer reported that by intensive efforts and a slight increase in the size of the Journal, the backlog of manuscripts awaiting publication in 1943 has been far reduced and prompter publication now is possible. The need for more manuscripts dealing with fish and fisheries problems was stressed.

D. I. Rasmussen reported for the committee which has been studying problems of re-districting the regional organization of the Society, particularly for the western states. A map was exhibited showing the existing regions and also the administrative subdivisions for several federal bureaus concerned with wildlife administration. After discussion, the problem was referred to the

incoming Council for further action.

There was extended discussion of the time and place of meeting of the Society, of its programs, and of its relations to the Wildlife Institute. Mention was made of the possibilities of meetings in connection with those of the American Fisheries Society or the American Association for the Advancement of Science. The Secretary was directed to inquire into possible representation of the Society on the Affiliation Committee of the A.A.A.S. Upon motion duly seconded and passed, the President and Council were directed to discuss with officers of the Wildlife Institute the role of the Society and its members in connection with meetings, particularly as to arranging and conducting technical sessions at the annual Wildlife Conferences.

Discussion of a possible news letter for members, particularly for those in the armed forces, led to passage of a motion that the Society issue such a news letter. Details as to form, time and frequency of issue, responsibility for gathering and editing the notes, etc., to be decided by the Council.

P. F. ENGLISH, *Secretary*

ANNUAL MEETING OF THE COUNCIL

The Council met in Chicago, Illinois, on the evening of April 23, 1944 with Messrs. Taylor, English, Wade, Goodrum, Pearce, and Swanson present. The following business was transacted:

1. Appointments: Membership Committee (2-year terms), P. R. Needham and A. L. Clark replacing T. H. Langlois and J. A. Johnson; Trustee (1944–47), C. T. Vorhies; Editor, T. I. Storer.

2. Editorial Committee requested to consider policy of printing reasonable number of papers on such subjects as objectives of the Wildlife Society, wildlife work as a profession, membership in the Society, and problems of practical conservation such as organization, administration, and law enforcement.

3. Incoming Council requested to formulate editorial policy as to classes of articles to appear in The Journal.

4. As to The Journal: (a) The October issue each year should carry a notice advising subscribers to renew their subscriptions in order to obtain the succeeding January issue on time; (b) Each member should provide the Secretary with a permanent mailing address; (c) Secretary should be notified of changes in address at least 30 days prior to publication of issue of Journal for which correction is to apply; (d) Society will not be responsible for copies of Journal mailed to other than such permanent address; (e) Society will not replace lost copies of Journal later than 60 days following date of publication of an issue; (f) Sale prices for back issues and volumes to be printed on cover of Journal; and (g) Foreign subscriptions should be remitted in equivalent of United States currency.

5. Members in arrears should be sent three successive notices (the last not later than October in second year of delinquency) before being considered delinquent. Those in arrears more than one year may be reinstated upon payment of current dues; they may obtain back issues in so far as available at current prices for such issues as set by the Council.

6. List of membership of the Society should be printed annually in The Journal.

7. Editor asked to attempt to obtain the allotment of paper formerly used in Wildlife News for use in The Journal.

8. In the event of a tie vote on a mail ballot, the Council shall decide the election.

9. The Secretary and Treasurer are authorized to hire a reasonable amount of clerical assistance to conduct necessary business of the Society, within the limits of available funds; all requisitions for stationery and other needed printing should first be approved by the Secretary.

10. Committee on Awards requested to consider improved design of scroll for the annual award.

11. Finance Committee requested to study the finances of the Society and to recommend a budget for the ensuing year.

12. Proposed amendments to the Constitution:

Art. III. Sec. 1. After the words "Associate Members" add "Life Members."

Art. III. Sec. 7. Any Active or Associate Member may become a Life Member by paying the sum of $100.00 at one time into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

Art. IV. Sec. 2. Delete the sentence "The President and Vice-President shall not succeed themselves."

Art. V. Sec. 1. In lieu of the phrase "close of the Annual Meeting" substitute "on May 1 following their election."

P. F. ENGLISH, *Secretary*

REPORT OF BALLOT COMMITTEE

The committee reports the following audit of the nomination and election ballots for The Wildlife Society for 1944–45:

1. NOMINATION BALLOTS. Total received, 113; late, 2; counted, 111 as follows: Region 1, 37; Region 2, 8; Region 3, 33; Region 4, 7; Region 5, 8; Region 6, 18. These checked with the tally by the Secretary and gave the following results:

President: 62 persons nominated; two highest: O. J. Murie, 69; G. O. Hendrickson, 51. (W. P. Taylor received 59 votes but, according to the constitution, the President cannot succeed himself.) *Vice-President:* 75 persons nominated; two qualifying, G. A. Swanson, 52; L. E. Yeager, 51. (O. J. Murie also received 51 votes but the Vice-President cannot succeed himself.) *Secretary:* 57 persons nominated; two highest P. F. English, 246; R. E. Trippensee, 15. R. W. Darrow received 18 votes but not being in good standing, was ineligible. *Treasurer:* 53 persons nominated; two highest D. E. Wade, 224; P. D. Dalke, 50.

Regional Representatives: Region 1: 24 nominations; highest John Pearce, 57; N. W. Hosley, 19. *Region* 2: 9 nominations; highest E. V. Komarek, 13; R. O. Stevens, 5; *Region* 3: 33 nominations; highest G. A. Swanson, 34; W. W. Chase, 14; *Region* 4: 8 nominations; highest O. J. Murie, 6; E. R. Kalmbach, 5; *Region* 5: 10 nominations; highest P. Goodrum, 7; H. L. Blakey, 6;

A. E. Borell, 6; W. P. Taylor, 6; *Region* 6: 14 nominations; two highest P. R. Needham, 29; D. I. Rasmussen, 17.

2. ELECTION BALLOTS. Total received, 212, as follows: Region 1, 56; Region 2, 19; Region 3, 71; Region 4, 12; Region 5, 18; and Region 6, 36. The Officers elected were: *President*, O. J. Murie; *Vice-President*, L. E. Yeager; *Secretary*, P. F. English; *Treasurer*, D. E. Wade.

Regional Representatives: Region 1, John Pearce; *Region* 2, E. V. Komarek; *Region* 3, W. W. Chase; *Region* 4, E. R. Kalmbach; *Region* 5, A. E. Borell; and *Region* 6, P. R. Needham.

We find the above correct and final as of April 18, 1944.

THE COMMITTEE:

E. W. Callenbach, Chairman
Randolph H. Thompson
Gordon L. Trembley

BRIEFER ARTICLES

APPLYING PRINCIPLES OF NAVAL AIRCRAFT RECOGNITION TO WILDLIFE STUDY

A training method now in use at the U. S. Navy Pre-flight Schools teaches student aviators to identify aircraft as friend or enemy in the split second during which they pass a gunner's sights. If this ability can be imparted to air cadets, there seems to be no reason why wildlife students could not be trained similarly to recognize birds, mammals, and possibly even plants just as quickly. This would provide great speed and accuracy in field identification and permit the teaching of field recognition of species far distant from the scene of schooling.

Recognition of airplanes and ships as developed and taught by the Navy to aviation cadets is by classroom instruction making use of illustrated texts, models, and projection slides. There is no field work except for incidental observations of passing planes while the cadets are engaged in other duties. Yet these cadets prove to be outstandingly superior when tested in the field in competition with self-taught personnel, some of whom have seen extensive recent action.

The split-second projection of photographs, by a standard projector equipped with a camera-type shutter, is the essence of the Navy course which continues even after the cadet joins the fleet as an aviator. Instant overall recognition of various craft is stressed, comprising rapid analysis of "field marks." To this end, exercises designed solely to develop wide angle vision supplement those attaining this purpose secondarily. Slides displaying figures consisting of from five to eight digits are flashed on the screen for intervals of from 1/10 to 1/25 of a second. Normal tendencies, such as reading from left to right, are thus overcome and replaced by overall vision. Five and six number figures are not difficult for amateurs to read but longer ones require practice.

"Counting" slides that display groups of flying planes or convoys of ships for about 1/50 of a second, require rapid estimation of the numbers of craft shown; these serve to develop wide angle vision and the ability to make accurate reports of the strengths of enemy fleets. In peacetime, such training might result in greater accuracy for aerial censuses of big game or estimates from the ground of the size of duck flocks, quail coveys, deer herds, or other animal groups.

Scores of different planes and ships are learned by naval aviation cadets during a single year from the observation of projected photographs and silhouettes, supplemented by the study of models and reference books. In the classroom, photographs are displayed first on the screen for several minutes while the instructor lectures on the points of identification. (For best economy of light, the projector is at the front of the room and aimed upward at an angle of about 30 degrees, and the screen is fixed at the supplementary angle.) Thereafter, regular reviews and tests are given daily with shutter speeds of from 1/25 to 1/75 of a second for airplanes and from one to three seconds for ships. Since the blink of an eyelid would prevent seeing an image, the instructor alerts his students with a "ready!", "now!", followed by the click of the shutter. Use of a large and varied library of slides prevents the cadets from learning individual pictures.

Applied to wildlife biology, this method should be of value for teaching professional students to identify accurately both birds and mammals by species (and by sex in some cases), even when only brief glimpses of them are possible. Waterfowl, shorebirds, birds of prey, game birds, gulls, terns, pigeons, woodpeckers, and many songbirds could be studied in various flight positions and some could also be shown as perched on wires or in trees. Longer exposures could be allowed where animals are pictured against dark backgrounds. The bounding flag of one fleeing white-tailed deer would no longer distract the novice mammal student from noticing the rest of the herd, if educated by this method. Botanical students likewise could acquire the ability to identify instantly plants of various families, winter browse species, leaf patterns, or flowers, by split-second projection. For amateurs, instantaneous identification contests would certainly enliven meetings of nature students and out-

doorsmen; and amateur naturalists reporting rarities for the first time could judge and have judged the value of their reports according to their previous "grades" in indoor sessions.

The author would be pleased to hear from anyone who applies or attempts these methods with scientific subjects.—GEORGE A. PETRIDES, U.S.N.R., *U. S. Navy Pre-Flight School, Athens, Ga.*

BOBWHITE QUAIL POPULATIONS ON HUNTED VS. PROTECTED AREAS

From 1939 through 1943, populations of bobwhite quail (*Colinus virginianus*) were censused intensively on about 2,400 to 3,100 acres of the Lake Carl Blackwell Project in Payne County, Oklahoma. Part of the area (530 to 600 acres, depending upon the lake level) was subjected to controlled hunting of quail each autumn and the remainder (1,870 to 2,500 acres) closed to hunting. Counts were made at the beginning of the breeding season (April 1), before the hunting season (November 1), and after the hunting season (January 1). To determine more accurately the effects of hunting, the counts, were reduced to birds per 100 acres:

		Hunted area	*Closed area*
1939,	April 1	11.0	9.4
	Nov. 1	25.0	12.6
	Jan. 1	11.0	12.0
1940,	April 1	3.1	2.2
	Nov. 1	9.8	8.9
	Jan. 1	7.1	8.4
1941,	April 1	6.8	8.0
	Nov. 1	21.8	13.2
	Jan. 1	10.9	12.3
1942,	April 1	11.6	11.9
	Nov. 1	24.7	14.7
	Jan. 1	17.4	13.9
1943,	April 1	10.6	13.0
	Nov. 1	18.5	15.0
	Jan. 1	9.4	13.9

Unquestionably the area hunted normally carried a higher autumn population than the larger area where hunting was prohibited; without exception the density of bobwhite each autumn on the former was slightly or considerably higher than on the closed area. Apparently the normal autumn population for the hunted area was about 20 to 25 birds per 100 acres and a comparable figure for the protected area was 12 to 15 birds. This difference in carrying capacity is believed to be due to the more favorable distribution of food and cover on the hunted area.

Unfavorable environmental conditions at times reduced the numbers of bobwhite far below the normal carrying capacity of the areas. For example, the sharp drop in numbers on both areas in 1940 resulted from die off of the birds in January apparently caused by lack of food in combination with a period of unusually severe weather. Throughout 1939 small rodents, particularly cotton rats (*Sigmodon hispidus*), were very abundant and consumed large quantities of seed-bearing grasses and weeds. This resulted in a shortage of food for seed-eating animals. Abnormally low temperatures prevailed from late December and throughout January. In addition, the ground was completely blanketed by three to six inches of snow for a 10-day period in January. As a result, conditions became critical for the bobwhite; some starved to death and many more became so weakened that they fell easy prey to natural enemies. The sharp decline in numbers on the hunted area in the spring of 1943 (end of hunting season 92; breeding population, 56) also was the result of unfavorable environmental conditions. Two fires in March burned over practically the entire hunting area and destroyed all ground vegetation except in the moist bottoms of ravines.

Reduction of the autumn population by hunting to approximately the normal breeding density did not result in a decline in numbers of birds from year to year. For example, if we assume that the 1939 nesting population of 11 per 100 acres was normal, the removal of approximately 20 to 55 per cent of the birds each autumn did not result in any conspicuous change in the breeding population from year to year, unless unfavorable environmental conditions reduced them below that

figure. It is possible that both the breeding and the autumn densities would have increased somewhat in the absence of hunting, but the writer is inclined to believe there would have been no pronounced change because the population on the closed area showed only limited fluctuations.

The ability of bobwhite to recover rapidly from heavy hunting losses, or from natural reduction in numbers, was also demonstrated clearly. The rapid recovery from a low level in the spring of 1940 was partly accelerated by heavy stocking with game farm birds, estimated to constitute approximately one fourth of the 1940 autumn population. By the autumn of 1941, following two favorable nesting seasons, the game farm birds had largely disappeared from the area and the number of wild birds was back to normal.—F. M. BAUMGARTNER, *Department of Entomology, Oklahoma A. and M. College, Stillwater, Oklahoma.*

VISCERAL GOUT IN A WILD RUFFED GROUSE

On November 5, 1943, an ailing adult ruffed grouse (*Bonasa umbellus sabini*) entered a poultry pen on the University Farm at the University of British Columbia in Vancouver. Although the bird partook of small amounts of green food, berries and water offered, it died two days later. During this brief captivity, the grouse suffered some diarrhoea in which white deposits of sodium urate predominated. Upon necropsy the cloaca and ureters were found to be filled with a white mass of pasty consistency. White deposits of urates were present on the ventral surface of the heart, concentrated along the coronary sinus, and on the left lobe of the liver. On these organs the general effect was as if flour had been sprinkled lightly over them (Pl. 13, *A*).

The primary lesions were confined to the kidneys, which, though but slightly enlarged, were pale in color and thickly studded with fine, punctate, white spots. Upon incision the kidneys were found to be friable. Fixation converted the texture to that of soft cement.

Portions of the liver and kidney were examined microscopically after fixation in Bouin's solution. As suggested by the gross findings, the major pathologic changes were confined to the kidneys. These organs contained many spherical or nearly spherical masses of urates measuring up to 390 micra in diameter. Most of these cyst-like bodies appear to have developed in the Malpighian corpuscles until few normal corpuscles remained (Pl. 13, *B*). In some places, however, they had developed in the collecting tubules (Pl. 13, *C*).

Necrotic changes were apparent in many renal tubules, which contained accumulations of urates. Another noteworthy feature was the pronounced variation in staining quality of the endothelium in many tubules. This may have resulted from the pathologic condition or from post mortem changes prior to fixation.

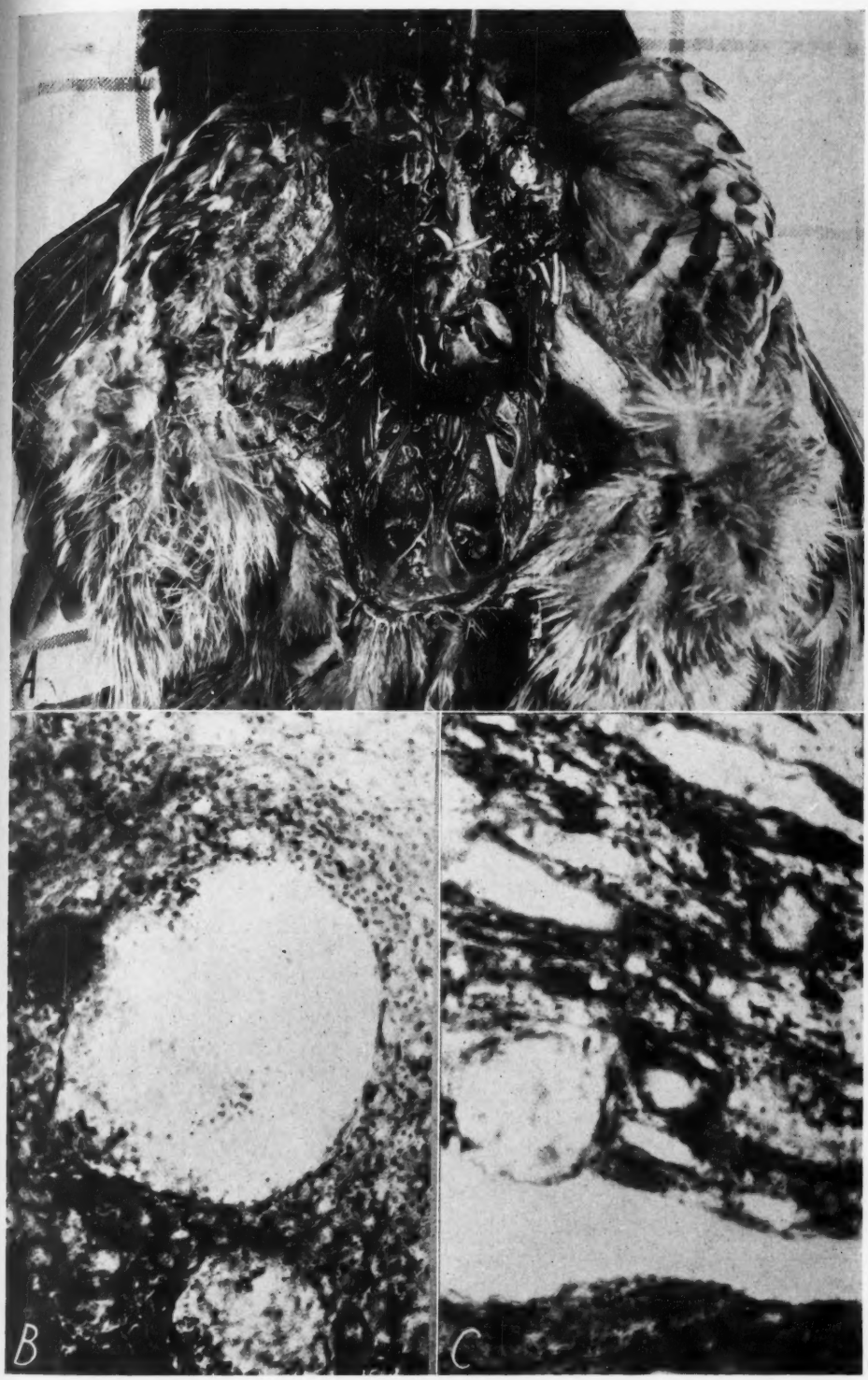
In the liver, the area immediately underlying the deposits of uremic sulphate showed necrosis and the nuclei failed to stain. Here it is believed that post mortem rather than pathological changes were responsible.

The above lesions had not previously been encountered by us in our studies of wildlife disease, but were readily identified by Mr. Jacob Biely of the Department of Poultry Husbandry.

Death of wild gallinaceous birds from visceral gout (uremic poisoning) has apparently not been recorded previously, but it is an ailment not infrequent in domesticated chickens under commercial and farm conditions. Generally, only one or two birds in a flock become affected. The disease is more or less sporadic in nature. Thus, of 235 pathologies in 215 birds which died at the 12th Western New York Egg Laying Contest 1942–43 six were attributed to visceral gout (Brunett, Hofstad and Levine: Western New York State Egg Laying Test, 1943 (Sept.): 8).

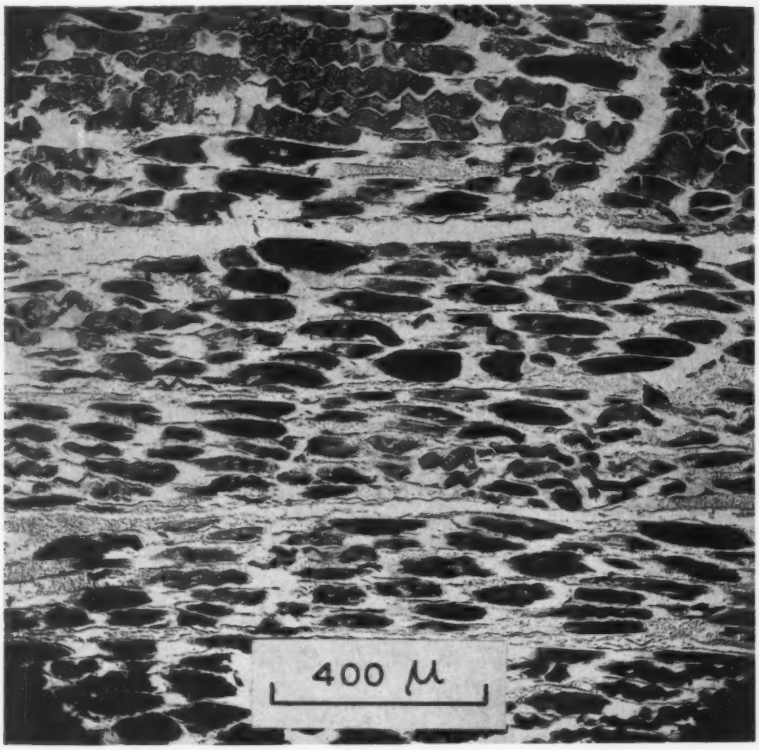
Witter (Thirteenth Maine Egg Laying Test; Maine Dept. Agric., 13(12): 13) reports that at the 1942–43 Contest, one of 23 hens and eight of 138 pullets autopsied were affected with internal gout (6) and articular gout (3).

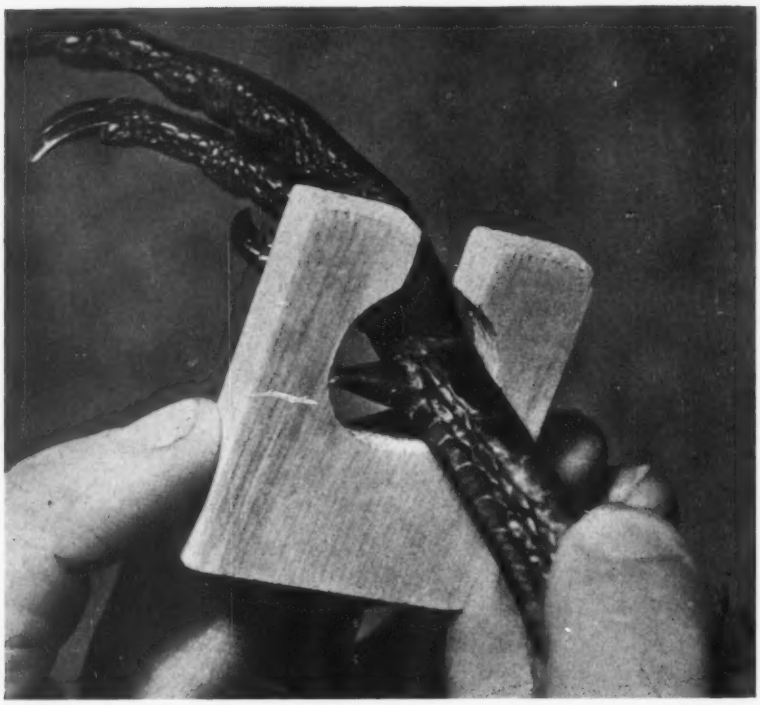
Biely (personal communication) reports that of 277 birds subjected to post-mortem



Visceral gout in wild ruffed grouse (*Bonasa u. sabini*).

A. Spotting of kidneys and accumulation of urates on liver and heart, as seen at necropsy. *B*. Accumulation of urates in a Malpighian corpuscle; ×200. *C*. Accumulation of urates in a collecting tubule; ×200.





Muscular dystrophy in young ring-necked pheasant.

Above. Voluntary muscle with many fibers transversely fragmented and swollen, with loss of fibrillar structure and altered staining reaction (black). Masson's trichrome stain.

Below. Device for age estimation of ring-necked pheasants. The bird used (young of the year by bursa determination) had one of the longest spurs found, yet it passed through the gauge. Note pale (ivory) tip on spur.

examination in his laboratory, 62 (22.38%) showed kidney disorders, often associated with visceral gout. Since all of these birds came from one flock, the high incidence of kidney disorders may be attributed to either (a) some deficiencies or excess in the ration, or (b) hereditary predisposition. Of the two, the latter would appear to be a more plausible explanation since the flock, as far as known, was fed a balanced ration moderate in protein content and well fortified with vitamin A.

Patterson (Veterinary Medicine, 24(2): 73, 1928) summarizes the cause of gout in fowls as: (1) feeding excessive amounts of nitrogenous concentrates; (2) close confinement; (3) green food deficiency; (4) individual susceptibility; and (5) impaired kidney function from any cause. In discussion of the malady, he obviously places greatest importance upon faulty nutrition and lack of exercise. There seems little possibility that either of these factors was involved in the grouse here described and the primary cause of its disease probably was constitutional.—I. McT. COWAN and C. D. FOWLE, *University of British Columbia, Vancouver, B. C.*

INAPPARENT MUSCULAR DYSTROPHY IN YOUNG RING-NECKED PHEASANTS

Pathological examinations of clinically normal ring-necked pheasants (*Phasianus c. torquatus*) from 14 breeders were made to obtain information on the health of Connecticut-bred birds to be liberated in the autumn of 1943. In the course of this work a hitherto undescribed affection of the voluntary muscles was observed.

Specimens[1] were collected by one of us (A.L.L.) from each flock at intervals of about 3 weeks. They varied from 8 to 18 weeks in age and from 250 to 880 grams in weight and had been fed on 8 different commercial brands of feed. Of the 49 birds used, there were employed 8 males and 41 females. Almost all of them were well-developed and in excellent flesh. Associated pathologic conditions were rather infrequent (10 cases, or 20.4%) and mild. Three showed yellowish diphtheritic plaques in the buccal cavity suggestive of former respiratory infection; two revealed isolated granulomatous foci in the liver suggesting old blackhead (histomoniasis) infection; two had light infestations of gapeworm (*Syngamus trachea*) in the windpipe; one showed marked sour crop (moniliasis), another a gizzard infection probably of traumatic origin, and the last had slipped tendon or perosis.

[1] Provided by the Connecticut Board of Fisheries and Game under its cooperative investigation with the Department of Animal Diseases of the Storrs Agricultural Experiment Station.

Pathologic examination revealed muscular dystrophy in four males and 14 females (18, or 36.7%), but this was not accompanied by recognizable clinical symptoms. The affected birds showed alterations in the breast muscle and to some extent in the superficial flexors (peroneus longus group), but the deep-lying tibialis anticus was normal. Severe changes were characterized by the appearance of fine whitish muscle fibers, alternating with pale normal fibers; these seemed to radiate symmetrically in a fan-like manner from the sternal crest toward the periphery. The anterolateral portions of the breast muscle often showed irregularly swollen areas of increased consistency, not sharply demarcated. In milder cases only certain portions of the breast muscle, usually the anterolateral aspects, were affected by formation of striae. Slight cases were recognizable by localized fish flesh-like changes of the musculature, or simple paleness. The lesions were classified arbitrarily, as to degree of severity of muscular dystrophy, as follows:

Degree	+	++	+++	++++
Number	3	7	5	3
Percentage	*17*	*39*	*28*	*17*

Histologic examinations of various organs were made on 8 negative and 10 positive dystrophy specimens. The kidneys, liver, heart, gizzard, gonads, pancreas, beak, and brain showed no definite lesions. In particular, the presence of neurolymphomatosis (1),

equine encephalomyelitis (2), and hypovitaminosis A (3), could be ruled out. Heavily affected muscles presented a variegated microscopic picture, mainly less striking than the gross appearance. Mild cases showed interstitial edema and occasional transverse fragmentation of muscle fibers. Intermediate cases also presented hyaline necrosis and loss of striate in isolated groups of fibers (Pl. 14); in an advanced case these changes extended over a large area. Save for scattered histiocytes, there was no marked cellular reaction; occasional multiple basophilic nuclei were observed in the affected fibers, indicative of incipient regeneration. The microscopic changes described embody the features of so-called Zenker's degeneration, and were considered characteristic of muscular dystrophy. Masson's trichrome stain was particularly effective in bringing out the extent of muscular damage.

TABLE 1.—RELATION OF WEIGHT TO INCIDENCE OF MUSCULAR DYSTROPHY IN RING-NECKED PHEASANTS.

Weight, grams	250–399	400–499	500–599	600–699	700–799	800–899	Males	Females
Number positive	4	7	3	2	1	1	4	14
Number negative	3	5	3	6	8	6	4	27
Percentage positive	*22*	*39*	*17*	*11*	*5*	*5*	*50*	*34*
Percentage negative	*10*	*16*	*10*	*19*	*26*	*19*	*50*	*66*

The muscular dystrophy did not seem to be related to sex. The data on age were incomplete; cases were found in birds 8 and 18 weeks of age—the limits of the age groups examined; the older lots, however, showed decrease in both incidence and severity of the muscle lesions. Weight records on the specimens were complete and indicated decreasing incidence with increased weight, an observation sustaining the impression gained from examination of the successive age groups (Table 1).

The cause of this muscular dystrophy is unknown. The lesions suggested a non-microbial degenerative condition resembling that reported in ducks (4) and in small laboratory mammals (5) fed a diet low in vitamin E. No correlation was apparent between the incidence of muscular dystrophy and type of feed since seven of eight commercial brands were used in flocks having positive cases. That the microscopic lesions were relatively mild and that voluntary muscles are endowed with high regenerative power may explain the lack of clinical symptoms. It is inconceivable, however, that the widespread pathologic changes observed in the muscles should not influence adversely the faculties of sustained mobility and coordination. Extended clinical tests and feeding experiments with rations low in vitamin E should be made.

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ERWIN JUNGHERR and REBECCA GIFFORD,
Storrs Agricultural Experiment Station, Storrs, Connecticut,
and
A. L. LAMSON,
State Board of Fisheries and Game, Hartford, Connecticut.

AGE GAUGE FOR PHEASANTS

It has been realized for some time that knowledge of the percentage of old birds as compared with birds of the year which are taken by hunters each season would be valuable in the management of the Nebraska population of pheasants. This age ratio is, of course, an excellent index of the year's productivity; if the percentage of young birds is relatively high, the degree of success in nesting and rearing is known to have been satisfactory. To be of greatest value, this information should be gathered from all sections of the state so that the relative productivity of various areas can be compared. The percentage of old birds taken each year is also of value as a final check on productivity in that year as compared with previous years.

During 1942 Levi Mohler (unpublished) had 382 male pheasants checked for age and spur length by professional game dressers in western Nebraska. The game dressers determined the age of each bird by the presence or absence of the bursa of Fabricius and recorded the spurs as short, medium, or long. Mohler found, with two exceptions, that the birds would have been classified correctly as to age by the spurs alone, all with long spurs being old birds. This showed the spur to be a rather reliable character for determining age; it was realized, however, that professional game dressers possess more than average skill in properly classifying the length of spurs. In central Nebraska, McClure has checked many pheasants and has had many others checked by game dressers. His data also show that the spur is a rather accurate means of determining age.

Because of the limited staff of biologists and the large area in Nebraska, it has been impossible for the Game Commission personnel to gather the desired amount of data on the age of pheasants taken. Hence, in the autumn of 1943, search was made for a method to determine the age of pheasant cocks which would be simple and foolproof enough for the layman and yet produce reasonably accurate results. With such a method it is believed that cooperating sportsmen in each county will furnish the desired data.

In the autumn of 1943, 50 birds were examined in northeast Nebraska. After making the bursa examination, the feet from each bird having medium-sized spurs (near ½ of an inch) were retained. The center toe was removed from each foot of the old bird to avoid later confusion. After a number of feet with medium spurs were obtained, calipers were used to determine which measurement

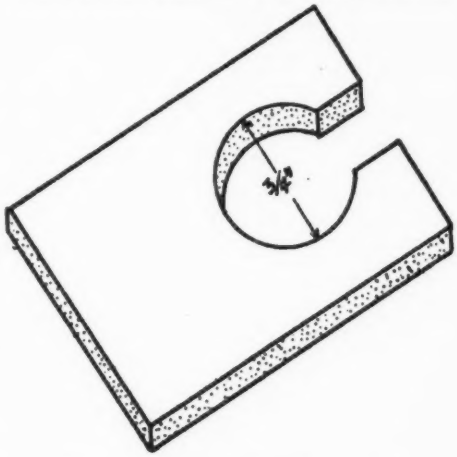

Fig. 1. Age gauge for pheasants.

showed the greatest variation between the young and the old. It was noticed that the spur lengthens and the tarsus also increases in size with age. The latter appears partly to result from heavier scalation of the leg. Because both the thickness of tarsus and length of spur increase with age, the greatest variation between the feet of young and old birds was found to be the distance between the tip of the spur and the opposite side of the leg.

Making a gauge which would slip over the leg and spur of a young bird but not on an old one proved to be simple because the desired dimension was found to be exactly three-quarters of an inch. A brace and ¾-inch bit, a saw, and a small piece of wood (pine lattice) were all that was needed to produce 50 gauges in two hours (Fig. 1).

The spur gauge meets the first qualification of being quick and simple to use—it may be applied in a second and is practically foolproof. The leg of a bird is slipped through the

notch into the ¾-inch hole; if the gauge will then slip down over the spur the bird is young (Pl. 14). The gauge has not yet been used enough to determine definitely its accuracy, but it seems to meet that qualification also.

The writer has checked 61 birds with the gauge and it has failed only twice—once on a young bird and the other on an old bird. This indicates that it should be satisfactory for the purpose intended. When many birds are being checked the compensating errors should improve this result (97%).

The ¾-inch hole seems to be correct for Nebraska, but the proper size may be different for other parts of the country where there are various strains of ring-necked pheasants. Because of the spur growth of young birds, the accuracy in use of the gauge will decrease as the season advances. It has been used through the first week of December and seems still to give accurate results up to that time of year.—JAMES W. KIMBALL, *Nebraska Game, Forestation and Parks Commission, Pierce, Nebraska.*

DEVICE FOR HOLDING LIVE WILD RATS

In studying wild mammals it is often necessary to examine living specimens in the hand. Mice and other small mammals can generally be held with the bare hands or with sturdy gloves as protection against biting, but rats and squirrels require means for special handling. Previous workers have used anaesthetics[1], cages with false tops which may be lowered to hold the animal against an open grating[2], or stretching boards to which the animals are transferred in a cloth zipper tube[3].

The device described below was developed to expedite the handling and marking of large series of wild-trapped Norway rats (*Rattus norvegicus*) in the field as part of a rat population study sponsored jointly by the Office of Scientific Research and Development and the City of Baltimore under the supervision of Dr. Curt P. Richter. It has proved successful in both field and laboratory studies with rats of two species and with gray squirrels (*Sciurus carolinensis*). Essentially it consists of a collapsible cone of stiff longitudinal wires with a short cloth sleeve at its base. A rat, having entered the cone through the sleeve, can be comfortably and safely held in the operator's hand. Examinations and manipulations are made through the ½ inch spaces between the wires; the feet are pulled through these spaces for toe-clipping.

A cone for rats from 50 to 600 grams is 10 inches long, 2¾ inches in diameter at its base and along its greater length, narrowing to a ¾ inch ring at its apex (Fig. 1). It is composed of sixteen 12-gauge steel wires hooked into as many evenly spaced holes in the terminal ring. Each wire is slightly bent three inches from the ring so that all lie parallel to each other, ½ inch apart, along the basal seven inches of the cone. The base of each wire is fastened to the sleeve. One or two stout cords encircling the cone and securely knotted to the wires prevent spreading of the spaces in the middle portion of the cone without hampering its collapsibility. The sleeve of sturdy cloth is about 5 inches in length, 2½ inches in diameter at its outer rim and 5 inches in diameter at its base where it is tacked to a light wooden frame adapted to the trap or cage against which it is to be applied. The top of a knitted work sock makes an effective, ready-made sleeve.

An adapter which supports the holder in the desirable stretched position consists of a board 1×6×17 inches, with a rigid upright support at one end for the basal frame of the holder and a hook or nail at the other end over which a loop at the apex of the holder may be slipped. After the door of the trap or cage has been opened and the rat has entered the holder, the operator grasps the base of the cone with one hand, releases the basal frame from the ridge on the floor of the adapter with the other, and then lifts the

[1] F. C. Evans and R. Holdenried, Journ. Mammalogy, **24**: 231, 1943.

[2] L. L. Baumgartner, Journ. Wildl. Mgt., **4**: 444, 1940.

[3] W. D. Fitzwater, Jr., Journ. Wildl. Mgt., **7**: 190, 1943.

holder with the rat clear from the adapter (Fig. 1). When handling small rats the holder is grasped far forward; with very large rats it is grasped by the sleeve. The sleeve is closed and the base of the cone drawn snugly around the rat by gently twisting the sleeve and laying the cone with the confined rat along the upper portion of the basal frame. The animal can then be set aside for weighing and other operations which require both of the operator's hands. A draw string with a sliding catch may be inserted in the sleeve if desired.

After an animal has been examined and treated, it can be released by returning the holder to its adapter and placing it in a horizontal or vertical position. Rats readily back out of the holder once the pressure around them has been released. As many as 20 or 30 rats may be handled (weighed, examined and marked or injected) in an hour by a single operator.

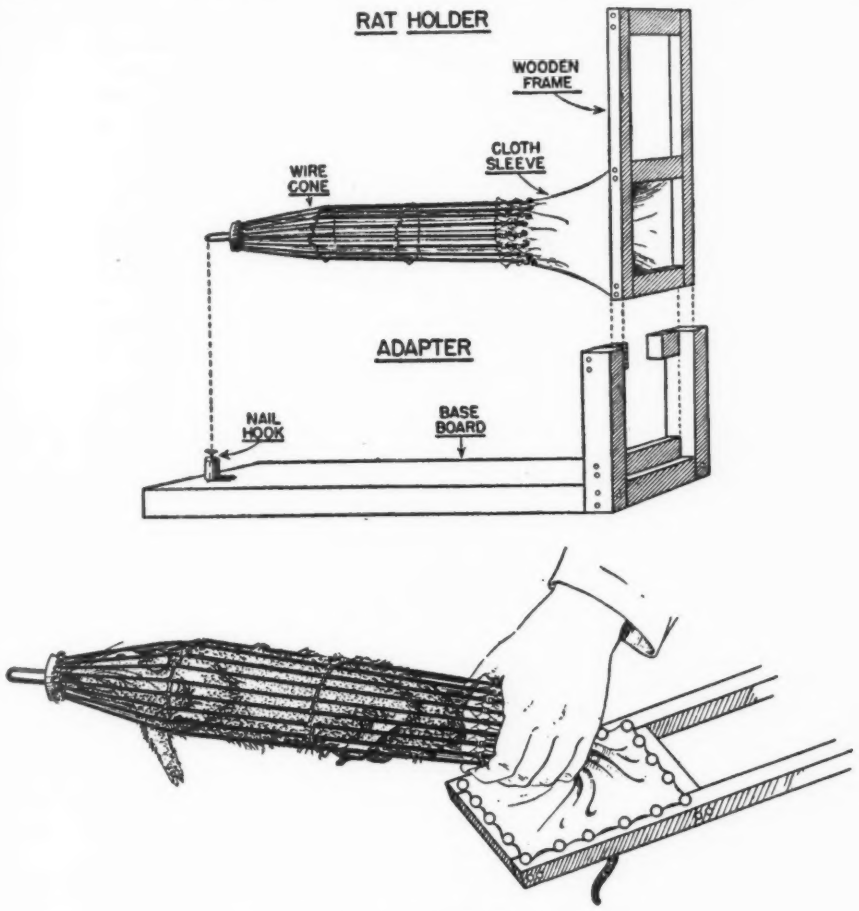

Fig. 1. Device for holding live wild rats.

The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Johns Hopkins Hospital.—JOHN T. EMLEN, JR., *Psychobiological Laboratory, Johns Hopkins Hospital, Baltimore, Maryland.*

COOPERATION OF SQUIRREL AND GROUSE

On November 5, 1943, Mr. J. J. Dunphy, Superintendent of the School Forest at the University of Maine, Orono, Maine, observed three ruffed grouse (*Bonasa umbellus*) grouped around a gray squirrel (*Sciurus carolinensis*) on one of the wood roads. The squirrel was busily dissecting white pine cones. As fast as it released the scales the partridges gobbled up the seeds, which, while still in the cone, were beyond their powers of extraction. Although witnessed by only one person, there is no reason to doubt the accuracy of the report of this incident, which may be unique in the annals of wildlife.—H. H. CHAPMAN, *School of Forestry, Yale University, New Haven, Conn.*

NEWS NOTES

The list of members in the armed forces, planned for this issue of the Journal, will be incorporated in the list of members of the Society which, by action of the Council, will be printed in the next issue.

The attention of members is directed to paragraphs 4 and 5 of the minutes of the meeting of the Council printed in this issue that deal with matters relating to addresses for mailing the Journal and the payment of dues.

The Ninth North American Wildlife Conference and meetings of associated organizations were held in the LaSalle Hotel, Chicago, Illinois, on April 24 to 26, 1944. Upwards of 700 persons were in attendance at the various programs. Since the printed Transactions of the Conference will not appear for some months, a summary of the program listing the speakers and titles of their papers is published here to indicate the scope and variety of subjects which were considered. As at the Denver meeting in 1943, considerable attention was given to wartime problems, but a number of papers dealt with postwar matters.

GENERAL SESSIONS

FORESTS AND SOILS

Chairman: P. J. Hoffmaster.

Some federal functions in wildlife and forest management. Lyle F. Watts, U. S. Forest Serv.

The functions of industry in wildlife and forest management. G. Harris Collingwood, Natl. Lumber Manf. Assn.

Soil fertility and wildlife, cause and effect. William A. Albrecht, Dept. of Soils, Univ. of Mo.

PLANS AND PROGRAMS

Chairman: Frederic C. Walcott.

Addresses by Juan Zinser representing the Republic of Mexico, J. A. Rodd and Harrison F. Lewis representing the Dominion of Canada, and The Honorable Claude R. Wickard, Secretary of Agriculture, and Ira N. Gabrielson of the Fish & Wildlife Service.

COORDINATED LAND MANAGEMENT

Chairman: Clifford C. Presnall.

Getting along with natural resources and people. Shirley W. Allen, Univ. Mich.

Broad public values inherent in land and water. Kenneth A. Reid, Izaak Walton League.

Wildlife, the public interest, and the law. P. R. Harris, Camp Fire Club of Amer.

Correlation of recreation with other public land uses. Robert Mann, Cook County Forest Preserve, Chicago.

Adjusting livestock and game production on public lands. Speaker for Amer. Natl. Livestock Assn. & Natl. Wool Growers' Assn.

ENGINEERING, HEALTH, AND RECLAMATION

Chairman: David A. Aylward.

Conservation in peace and war. Brig. Gen. John J. Kingman, U. S. Army.

Joint interests of health and conservation agencies. J. K. Hoskins, U. S. Publ. Health Serv.

Reclamation projects conserve wildlife. William E. Warne, U. S. Bur. of Reclamation.

TECHNICAL SESSIONS

BIG GAME MANAGEMENT

Chairman: D. I. Rasmussen.

Restoration of wild bison. Victor H. Cahalane, Natl. Park Serv., Chicago.

A study of the carrying capacity of deeryards as determined by browse plots. W. Carl Gower, Dept. of Cons., Lansing, Mich.

Roadside deer counts as an emergency census method. Thomas A. Schrader, Dept. of Cons., St. Paul, Minn.

Some results of a study of mule deer in central Utah. Orange A. Olsen, U. S. Forest Serv., Ogden, Utah.

Our big game in winter. Olaus J. Murie, U. S. Fish & Wildlife Serv., Jackson, Wyo.

Arkansas' deer transplanting program. Roy Wood, Ark. Game & Fish Comm., Little Rock.

The Murder's Creek mule deer herd. Glen E. Mitchell, U. S. Forest Serv., Portland, Ore.

Fish Management

Chairman: H. S. Swingle.

Factors affecting the growth of fish. John Van Oosten, Fish & Wildlife Serv., Ann Arbor, Mich.

Effect of species combinations on fish production. G. W. Bennett, State Nat. Hist. Surv., Urbana, Ill.

The place of stocking in a fish management program. A. S. Hazzard, Inst. for Fisheries Res., Ann Arbor, Mich.

The role of legal restrictions in fish management. T. H. Langlois, Franz Theodore Stone Lab., Put-In-Bay, Ohio.

Harvesting the fish crop. R. W. Eschmeyer, Tenn. Valley Authority.

Increasing the production of food for fish. Stillman Wright, U. S. Fish & Wildlife Serv., Logan, Utah.

Miscellaneous problems of competition and predation. Karl F. Lagler, Univ. Mich., Ann Arbor.

Commercial Fisheries

Chairman: Edward W. Allen.

Cooperation between game and commercial fishery interests. Charles E. Jackson, Fish & Wildlife Serv.

Deep-sea operators' conservation viewpoint. Frederick McG. Bundy, Groton-Pew Fisheries Co. Ltd., Gloucester, Mass.

Legal aspects of coastal fisheries. Joseph Walter Bingham, Stanford Univ.

Maintaining the supply. Wm. C. Harrington, Fish & Wildlife Serv., Boston, Mass.

The processors' interest in seafood conservation. J. L. Alphen, Mass. General Seafoods Corp., Boston, Mass.

Marine resources of southern New England and analysis of Connecticut trawl fisheries. Daniel Merriman & Herbert E. Warfel, Bingham Oceanographic Lab., New Haven, Conn.

Waterfowl

Chairman: Frederick C. Lincoln.

Managing the resource. Ira N. Gabrielson, Fish & Wildlife Serv.

Waterfowl refuge administration in war time. Arthur C. Elmer, Fish & Wildlife Serv.

Game law enforcement. W. E. Crouch, Fish & Wildlife Serv.

Canadian waterfowl management problems. J. Dewey Soper, Canadian Natl. Parks Bur.

Control of waterfowl depredations. Albert M. Day, Fish & Wildlife Serv.

Control of obnoxious plants in waterfowl habitats. Francis M. Uhler, Fish & Wildlife Serv.

Post-war planning for waterfowl. Clarence Cottam, Fish & Wildlife Serv.

Upland Game Management

Chairman: Frank C. Edminster.

A cooperative approach to farm game management. Clarence W. Watson, Fish & Wildlife Serv., Atlanta, Ga.

The development of waste areas on the farm for upland game cover. J. W. Kimball, Game, Forestation & Park Comm., Lincoln, Nebr.

Wildlife relationships to soil types. A. H. Denney, Mo. Cons. Comm., Jefferson City, Mo.

The "crash" decline in sharp-tailed grouse and Hungarian partridge in western Canada and the role of the predator. B. W. Cartwright, Ducks Unlimited, Winnipeg, Man.

The significance of population turnover in

upland game management. M. O. Steen, Fish & Wildlife Serv., Minneapolis, Minn.

A theory of pheasant management for North Dakota. Roy N. Bach. N. Dak. Fish & Game Dept., Bismarck, N. Dak.

Populations, hunting pressure, and movement of the raccoon in Ohio. Robert T. Butterfield, Ohio Div. of Cons., Frazeysburg, Ohio.

THE FUNCTIONS OF WILDLIFE AND CONSERVATION EDUCATION

Chairman: Douglas E. Wade.

Papers by George O. Hendrickson, Iowa State Coll., Livingston E. Osborn, Ill. Dept. of Cons., E. Laurence Palmer, Cornell Univ., Walter P. Taylor, Fish and Wildlife Serv., and Carl W. Buchheister, Natl. Audubon Soc.

REVIEW

The Biotic Provinces of North America. Lee R. Dice. Ann Arbor, University of Michigan Press. viii+78 pp., 1 map. 1943. $1.75.

Efforts to recognize and map the distinctive biological subdivisions of the earth have been made for more than a century. These have ranged from worldwide surveys such as that of Wallace to refined ecologic maps of small areas. A miscellany of classifications has been proposed by realms, regions, provinces, biomes, or life zones that vary in size, terminology, and other respects, until only specialists in this field are able to comprehend the subject. Dice defines a *biotic province* as "a considerable and continuous geographic area . . . characterized by the occurrence of one or more important ecologic associations that differ, at least in proportional area covered, from the associations of adjacent provinces." In general, each has ". . . peculiarities of vegetation type, ecological climax, flora, fauna, climate, physiography, and soil." In any province, a continuous subdivision is termed a *biotic district* and a vertical subdivision of a province, frequently not continuous, is a *life belt.* "Each biotic province comprises both the climax communities and all the successional stages within its area . . . ," including fresh water but not marine communities. Boundaries usually are difficult to locate precisely; one means is draw a line where the dominant associations of two provinces cover approximately equal areas.

Upon these rather vague specifications, the author divides North America, from Mexico to the Arctic, into 28 biotic provinces, designated mainly by names used previously by other authors. For each biotic province there is a brief discussion of its boundaries and of its physical and biological characteristics, mention of prior areal names used, and of some pertinent faunal and floral publications.

This book will be useful mainly as a rough guide to the biological subdivisions of North America, but in the absence of lists of characteristic species of plants and animals it does not afford the more precise comparisons available in some other works on geographical distribution.—TRACY I. STORER.